## Comparative Summary Tables

The following tables summarize the more diagnostically useful data in the species accounts in a convenient comparative format and supplement the species accounts with comparative information on pigmentation and special characters. All data in these tables are included in the computer-interactive keys, but along with the descriptive species accounts, these tables are provided to help confirm identities determined through the keys or as an alternative to the keys.

The tables are organized in three sets of six tables for the native catostomids, native cyprinids, and non-native cyprinids, respectively. Each set includes a table comparing size at the onset of selected developmental events (Tables 58, 65, 71), selected meristics (Tables 59, 66, 72), the more diagnostically useful morphometrics (Tables 60, 67, 73), size relative to pigmentation of the eyes and body in protolarvae and peritoneal pigmentation in metalarvae and early juveniles (Tables 61, 68, 74), selected melanophore pigmentation patterns, coded by developmental phase (Tables 62, 69, 75), and miscellaneous other characters (Tables 63, 70, 76). The catostomid set also includes a seventh table (Table 64) comparing dimensions of the frontoparietal fontanelle.

## Native Catostomids

**Table 58.** Comparison of size (mm SL) at onset of or transition to developmental intervals, gut phases, and other developmental events for larvae and early juveniles of native catostomids of the Gila River Basin. (Rare values in parentheses.)

| Character | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| **Egg diameter** | 3.0-3.4 | (3.0-)3.2-3.6 | 3.8-3.9 | 2.5-2.8 |
| **Phase/period transitions** | | | | |
| Embryo to larva | (8)9-10 | 9-10(11) | (8-)10-11 | 7-9 |
| Protolarva to flexion mesolarva | (10)11-12 | (12)13-14 | 13 | (10)11(12) |
| Flexion to postflexion mesolarva | (13)14(15) | (13)14-16 | (14)15(16) | (11)12-13 |
| Postflexion mesolarva to metalarva | (15)16(-18) | (18)19-21(22) | 19-20(21) | 15-17 |
| Metalarva to juvenile | (22)23-24(25) | (24)25-26 | 23-24(25) | (21)22-23(24) |
| **Gut phase transitions** | | | | |
| 1 to 2 (90° bend) | (13)14-15(16) | (18)19-20 | (17)18(-20) | (14)15(-17) |
| 2 to 3 (full loop) | (15)16-17 | 22 | (19-)21-25(-27) | 17 |
| 3 to 4 (partial crossover) | (16)17(18) | (24)25-26 | (22)23-32(-37) | 18-25(26) |
| 4 to 5 (full crossover) | 18-19 | (31)32-33 | (29-)35-42 | (22-)26-28(-31) |
| **Onset of selected events** | | | | |
| Eyes pigmented | 10 | 11 | (9)10 [a] | (7)8(9) [a] |
| Yolk assimilated | 12-14 | (13)14-16 | (14)15(16) | (9)10-11 |
| Finfold absorbed | (22)23-24(25) | (24)25-26 | 23-24(25) | (21)22-23(24) |
| Pectoral-fin buds | [a] | [a] | (9) [a] | 7 [a] |
| Pelvic-fin buds | 13-14 | 14-16 | (15)16(17) | (13)14 |
| **Fin rays first observed** | | | | |
| Dorsal, principal | 13-14 | 14-15 | 15 | 13-14 |
| Anal, principal | 15-16 | 18 | 17 | (13-)15 |
| Caudal, principal | (10)11-12 | (12)13-14 | 13 | (10)11(12) |
| Caudal, rudimentary | 13-14 | 16-17 | (15-)17 | 14 |
| Pectoral | (13)14-15 | 17-18 | 17 | (13-)15 |
| Pelvic | 15-16 | 18-19(20) | 17-18 | (13-)15-17 |
| **Full fin ray counts first observed** | | | | |
| Dorsal, principal | (14)15-16 | 18 | 17-18 | 15(-17) |
| Anal, principal | (15)16(-18) | (18)19-21(22) | 19-20(21) | 15-17 |
| Caudal, principal | (13)14(15) | (13)14-16 | (14)15(16) | (11)12-13 |
| Caudal, rudimentary | 21-23(-25) | 21-24 | 23 | 19-20(-24) |
| Pectoral | 18 | 22-23 | 19-22 | 16-18 |
| Pelvic | (18)19-20 | 21(22) | 23 | 16-17 |
| **Scales, lateral series** | | | | |
| First observed | 28-29 | 30-31 | (36)37-39 | 24-28 |
| Full series first observed | 29-34 | 32-33 | 39-42 | 33-36(37) |

[a] (Or) before hatching.

**Table 59.** Comparison of selected meristics for larvae and early juveniles of native catostomids of the Gila River Basin. (Character range is followed by the mean or more typical range. See Figure 4 for methods of counting myomeres and fin rays. ODF = origin of dorsal finfold, OP2 = origin of pelvic buds or fins, PV = posterior margin of the vent. Vertebra counts include four for the Weberian complex; dorsal-fin-ray counts are of principal rays; scale counts are of the lateral line or series. Data previously published by other authors are given in parentheses; references are listed in corresponding species accounts.)

| Character | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| **Myomeres to ODF** | | | | |
| Protolarvae | 13-16, 15 | 10-14, 12 | 10-15, 12 | 10-16, 12 |
| Flexion mesolarvae | 12-18, 16 | 11-15, 14 | 12-15, 13 | 12-16, 13 |
| Postflexion mesolarvae | 15-18, 16 | 13-17, 15 | 12-17, 15 | 12-17, 14 |
| **Myomeres to OP2** | | | | |
| Postflexion mesolarvae | 22-24, 23 | 20-22, 21 | 19-23, 21 | 19-22, 20 |
| Metalarvae | 22-26, 24 | 20-22, 21 | 21-24, 22 | 19-22, 20 |
| **Myomeres to PV** | | | | |
| Proto- & mesolarvae | 38-42, 40 | 37-41, 39 | 37-40, 39 | 37-41, 38-39 |
| Metalarvae | 36-40, 38 | 36-39, 37 | 36-38, 37 | 36-39, 37 |
| All larvae | 36-42, 38-40 | 36-41, 37-39 | 36-40, 37-39 | 36-41, 37-39 |
| **Myomeres, total** | | | | |
| Proto- & mesolarvae | 47-49, 48 | 46-49, 47-48 | 47-49, 48 | 46-49, 47-48 |
| Metalarvae | 47-51, 49 | 46-50, 48 | 46-48, 47 | 44-48, 46 |
| All larvae | 47-51, 48-49 | 46-50, 47-48 | 46-49, 47-48 | 44-49, 46-48 |
| **Vertebrae** | 46-48 | 47-48 | 47-50 | 45-47, 46 |
| | (45-51, 46-49) | – | – | – |
| **Dorsal-fin rays** | 10-12, 10-11 | 10-12, 11 | 11-14, 12-13 | 12-16, 14-15 |
| | (8-12, 10-11) | (10-13, 11-12) | (10-15, 12-13) | (12-16,14-15) |
| **Lateral-line scales** | 70-75 | 51-58, 53-58 | – | – |
| | (61-104, 67-95) | (54-67, 60-62) | (89-120,98-105) | (68-95,76-87) |

**Table 60.** Comparison of the more diagnostic differences in morphometrics for larvae and juveniles (≤40 mm SL) of native catostomids of the Gila River Basin. (Except as indicated, all data are percentages of standard length, % SL, presented as ranges followed by means. HL = head length measured to the origin of the pectoral fin, AS to OP1. See Figure 4 for other abbreviations and methods of measurement.)

| Developmental Phase<br>Character | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| **Protolarvae (with pigmented eyes)** | | | | |
| Eye diameter [a] | 6-8, 7 | 6-8, 7 | 5-6, 5 | 5-6, 6 |
| Eye diameter, % HL [a] | 39-45, 42 | 38-49, 43 | 34-40, 37 | 31-38, 35 |
| AS-to-ODF length | 34-42, 39 | 33-38, 35 | 33-38, 35 | 32-39, 34 |
| Yolk length [b] | 58-63, 61 | 54-66, 62 | 54-67, 61 | 0-68, 44 |
| Pectoral-fin length | 3-8, 6 | 3-10, 5 | 3-9, 6 | 3-11, 7 |
| Depth at BPE [b] | 9-11, 10 | 8-11, 9 | 7-9, 8 | 8-10, 9 |
| Depth at OP1 [b] | 10-15, 12 | 10-13, 12 | 8-10, 9 | 9-12, 11 |
| Depth at OD [b,c] | 11-19, 15 | 11-18, 15 | 13-15, 14 | 7-13, 10 |
| Max. yolk depth [b] | 9-18, 12 | 9-20, 12 | 9-16, 12 | 0-9, 5 |
| Width at OD [b,c] | 9-16, 12 | 8-19, 11 | 7-11, 10 | 4-9, 6 |
| Max. yolk width [b] | 12-18, 14 | 8-18, 12 | 9-18, 13 | 0-9, 5 |
| **Flexion mesolarvae** | | | | |
| Eye diameter, % HL [a] | 33-42, 38 | 35-42, 39 | 32-37, 34 | 28-39, 34 |
| AS-to-OPAF length | 19-26, 23 | 22-29, 25 | 22-32, 26 | 24-30, 27 |
| AS-to-PV length | 76-80, 78 | 77-80, 78 | 75-78, 77 | 78-81, 79 |
| Yolk length | 0-59, 48 | 0-58, 43 | 0-54, 42 | 0-50, 4 |
| Depth at OP1 | 11-13, 12 | 11-14, 12 | 10-12, 11 | 10-14, 13 |
| Depth at AMPM | 4-5, 4 | 4-5, 5 | 3-4, 3 | 3-5, 4 |
| Max. yolk depth | 0-8, 5 | 0-9, 4 | 0-9, 5 | 0-2, 0 |
| Width at OD | 5-9, 7 | 5-10, 7 | 5-8, 6 | 5-6, 5 |
| Max. yolk width | 0-10, 7 | 0-10, 5 | 0-9, 5 | 0-5, 0 |
| **Postflexion mesolarvae** | | | | |
| Eye diameter, % HL [a] | 28-33, 30 | 29-38, 32 | 24-35, 27 | 27-33, 30 |
| AS-to-OP2 length | 54-57, 56 | 50-56, 52 | 50-54, 53 | 50-54, 52 |
| AS-to-ODF length | 43-47, 45 | 39-47, 42 | 36-48, 44 | 36-45, 42 |
| AS-to-OD length | 47-50, 49 | 47-50, 48 | 49-51, 50 | 47-51, 49 |
| AS-to-ID length [d,e] | 59-66, 63 | 62-65, 63 | 62-67, 64 | 65-67, 66 |
| AS-to-PV length | 79-82, 81 | 78-81, 80 | 76-80, 78 | 78-84, 81 |
| AS-to-OA length | 78-79, 79 | 77-80, 79 | 76-80, 78 | 79-82, 81 |
| AS-to-IA length [f] | 85-85, 85 | 86-86, 86 | 83-84, 84 | 85-86, 86 |
| Dorsal-fin-base length [d,e,g] | 11-17, 14 | 15-16, 15 | 12-17, 15 | 16-18, 17 |
| Yolk length | 0 | 0 | 0-46, 7 | 0 |
| Depth at BPE | 14-17, 15 | 12-17, 14 | 11-16, 13 | 11-16, 13 |
| Max. yolk depth | 0 | 0 | 0-3, 0 | 0 |
| Width at BPE | 13-16, 14 | 11-16, 13 | 10-15, 13 | 11-14, 12 |
| Max. yolk width | 0 | 0 | 0-5, 1 | 0 |
| **Metalarvae** | | | | |
| Eye diameter, % HL [a] | 24-31, 28 | 24-30, 27 | 22-25, 24 | 24-32, 27 |
| AS-to-PE length | 12-15,14 | 13-17, 15 | 12-14, 13 | 12-17, 14 |
| AS-to-OP1 length | 23-27, 25 | 26-30, 28 | 24-28, 26 | 25-30, 27 |
| AS-to-OP2 length | 54-61, 58 | 52-58, 56 | 52-57, 55 | 51-58, 56 |
| AS-to-ID length [e] | 63-66, 64 | 64-66, 65 | 62-67, 65 | 65-69, 67 |
| AS-to-OA length | 75-79, 76 | 75-78, 76 | 74-78, 75 | 76-79, 77 |
| AS-to-IA length | 82-86, 84 | 83-86, 85 | 81-84, 82 | 83-86, 84 |
| Caudal-fin length [h] | 14-21, 18 | 17-24, 20 | 17-25, 22 | 20-28, 23 |
| Dorsal-fin (D) length [e] | 20-23, 22 | 22-26, 23 | 20-24, 22 | 21-29, 24 |
| Dorsal-fin-base length [e,g] | 14-18, 16 | 15-18, 16 | 14-17, 16 | 16-21, 18 |
| Depth at BPE | 15-18, 17 | 17-20, 18 | 15-17, 16 | 15-18, 16 |
| Width at BPE | 15-18, 16 | 16-19, 17 | 14-17, 16 | 14-17, 15 |
| Width at OD | 11-19, 15 | 12-16, 14 | 10-15, 12 | 8-15, 11 |

(continued)

**Table 60.** Continued.

| Developmental Phase Character | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| **Juveniles <40 mm SL** | | | | |
| Eye diameter, % HL [a] | 22-29, 26 | 21-27, 24 | 19-26, 23 | 21-30, 25 |
| AS-to-AE length | 7-11, 9 | 8-11, 10 | 7-10, 8 | 6-9, 8 |
| AS-to-PE length | 14-17, 15 | 16-18, 17 | 13-15, 14 | 13-16, 15 |
| AS-to-OP1 length | 24-27, 26 | 27-31, 29 | 24-28, 25 | 25-31, 28 |
| AS-to-OP2 length | 57-60, 58 | 54-58, 57 | 52-57, 55 | 54-60, 57 |
| AS-to-OD length | 47-50, 49 | 48-51, 50 | 46-49, 48 | 46-52, 49 |
| AS-to-ID length [e] | 64-66, 65 | 64-67, 66 | 61-66, 65 | 65-70, 67 |
| AS-to-PV length | 74-76, 75 | 75-77, 76 | 72-76, 74 | 75-80, 77 |
| AS-to-OA length | 74-76, 75 | 74-77, 76 | 72-77, 75 | 75-80, 78 |
| AS-to-IA length | 82-84, 83 | 83-85, 84 | 80-85, 82 | 82-86, 84 |
| Caudal-fin length [h] | 15-21, 17 | 19-23, 21 | 21-25, 23 | 23-28, 25 |
| Dorsal-fin (D) length [e] | 22-25, 23 | 22-26, 24 | 23-26, 24 | 23-29, 27 |
| Dorsal-fin-base length [e,g] | 14-18, 16 | 14-19, 16 | 14-18, 16 | 16-20, 18 |
| Anal-fin (A) length | 12-18, 15 | 15-17, 16 | 12-16, 14 | 12-18, 15 |
| Depth at BPE | 17-18, 17 | 18-19, 19 | 15-17, 16 | 16-20, 18 |
| Depth at OP1 | 19-23, 21 | 22-24, 23 | 17-22, 19 | 20-23, 22 |
| Depth at OD | 18-22, 21 | 20-24, 22 | 17-22, 19 | 18-27, 23 |
| Depth at BPV | 10-12, 11 | 11-13, 12 | 10-13, 11 | 11-14, 13 |
| Width at BPE | 16-18, 17 | 17-18, 18 | 15-17, 15 | 15-18, 16 |
| Width at OP1 | 17-20, 18 | 17-20, 18 | 14-17, 16 | 15-20, 18 |

[a] Eye diameter = (AS to PE)-(AS to AE).
[b] Ignore differences in maximum values since they may be affected by developmental state at hatching.
[c] OD for protolarvae and early flexion mesolarvae is approximated at one-half of standard length (AS to PHP).
[d] Applicable only to specimens with a full complement of dorsal-fin pterygiophores or principal rays.
[e] For *Xyrauchen texanus* with a rare count of only 12 or 13 principal dorsal-fin rays, lengths for this character may be less than the range reported herein (all specimens analyzed for these measures had ≥14 principal dorsal-fin rays or pterygiophores).
[f] Applicable only to specimens with a full complement of anal-fin pterygiophores.
[g] Dorsal-fin base = (AS to ID)-(AS to OD).
[h] Caudal-fin length = (AS to PC)-(AS to PHP), total length minus standard length.

**Table 61.** Comparison of size (mm SL) relative to melanophore pigmentation of the eyes and bodies for protolarvae and lateral to ventral peritoneum for postflexion mesolarvae (P), metalarvae (M), and early juveniles (J, ≤40 mm SL) of native catostomids of the Gila River Basin. (For peritoneal pigmentation, size is preceded by initials for the applicable developmental intervals. Rare values are given in parentheses.)

| Character | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| **Eye pigmentation, protolarvae** [a] | | | | |
| Unpigmented | ≤10 | ≤11 | ≤10 | ≤9 |
| Light to moderate | 10-12 | 11-13 | 9-11 | 7-10 |
| Dark | ≥(10)11 | ≥(12)13 | ≥11 | ≥9 |
| **Body pigmentation, protolarvae** [a] | | | | |
| Unpigmented | ≤10 | ≤11(12) | ≤10 | ≤11 |
| 1-12 melanophores on dorsum | 10 | 12 | 9-11 | 8-12 |
| ≥13 melanophores on dorsum | ≥(10)11 | ≥12 | ≥11 | ≥9 |
| **Peritoneal pigmentation** [b] | | | | |
| Lateral, P and M only [c] | | | | |
| Absent | – | PM all | PM ≤22 | PM ≤24 |
| Sparse or patchy | PM ≤17 | PM ≥(16)17 | PM ≥19 | PM ≥14 |
| Uniformly light | PM ≤21 | (M ≥21) | – | – |
| Uniformly dark | PM ≥15 | – | – | – |
| Ventrolateral surfaces | | | | |
| Absent (or obscured in J) | P ≤16 | PMJ all | PMJ all | PMJ all |
| Sparse or patchy | PM 14-21 | (PMJ ≥18) | MJ ≥23 | MJ 20-37 |
| Uniformly light | PM 15-21 | – | (J ≥35) | (J 26-37) |
| Uniformly dark | MJ ≥(17)18 | – | (J ≥38) | (J 35-37) |
| Ventral surface | | | | |
| Absent | PM ≤21 | PMJ all | PMJ all | PMJ all |
| Sparse or patchy | PM 15-21 | – | MJ ≥22 | J 23-37 |
| Uniformly light | MJ 17-21(-29) | – | (J ≥38) | J ≥29 |
| Uniformly dark | MJ ≥18 | – | (J ≥38) | J ≥32 |

[a] Some to most specimens of each species will hatch with eyes or eyes and body well pigmented.

[b] Pigmentation of the peritoneum is subsurface and should not be confused with surface or cutaneous pigmentation. Also, pigment might be apparent in the dorsal and dorsolateral portions of the peritoneum of smaller larvae and should not be interpreted as pigment in the lateral region.

[c] In juveniles, lateral pigmentation of the peritoneum usually is obscured by muscle.

**Table 62.** Comparison of selected melanophore pigmentation patterns for larvae and juveniles (≤40 SL) of native catostomids of the Gila River Basin. (Key to characters and their states is given below. Character numbers correspond to those in the computer-interactive key. Rare character states are enclosed in parentheses. NA = not applicable.)

| Character number | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| **Protolarvae** (after pigment is well established) | | | | |
| 22. | (1),2 | 1-2 | 1-2 | 1-2 |
| 23. | 1-3 | 1 | 1 | 1 |
| 24. | 1-2,(3) | 2-3 | 1-3 | 1-3 |
| 25. | 1 | (2),3 | 2-3 | 2-3 |
| 38. | 1 | 1 | 1 | 1,(2) |
| 39. | 1,(2) | 1 | 1 | 1-2,(3) |
| 40. | 1 | 1 | 1-2 | 1-2 |
| 41. | (1-2),3-4 | 1-2 | 1-3 | 1-2 |
| 54. | 1 | 1 | 1 | 1 |
| **Flexion Mesolarvae** | | | | |
| 21. | (2),3 | (1-2),3 | 1-3 | 1-3 |
| 22. | 2 | 2 | 2 | 1-2 |
| 23. | 2-3 | 1 | 1 | 1 |
| 24. | 1-2,(3) | 2 | 1-2 | 1-3 |
| 25. | 1 | (2),3 | 2-3 | 2-3 |
| 26. | NA | 1-2 | 1-2 | 1 |
| 31. | (1),2-3 | (1),2-3 | 2-3 | 1-3 |
| 32. | 3 | 1-3 | 1-2 | 1 |
| 33. | (2),3 | 1-2 | 1 | 1 |
| 38. | 1-2 | 1,(2) | 1 | 1-2 |
| 39. | 1-3 | 1 | 1 | 1-3 |
| 40. | (1),2 | 1-2 | 1-2 | 1-2 |
| 41. | (1-2),3-5 | 1-4,(5) | (1),2-3,(4) | 1-2 |
| 54. | (1),2 | 1-2 | 1 | 1 |
| 55. | 2-4 | 1 | 1,(2,4) | 1 |
| **Postflexion Mesolarvae** | | | | |
| 21. | 3 | 3 | (1),2-3 | (1),2-3 |
| 23. | 2 | 1-2,(3) | 1-3 | 1,(2-3) |
| 24. | 2 | 1-2 | 1,(2) | 1-2 |
| 25. | 1 | 1-3 | 1-3 | 1-2,(3) |
| 26. | NA | 2,NA | (1),2,NA | 1,NA |
| 27. | 1 | 1 | (1),2 | 1-2 |
| 31. | 3 | 3 | 2-3 | (2),3 |
| 32. | 3 | (1-2),3 | 1-3 | 1-3 |
| 33. | 3 | 1-3 | 1-2 | 1-2 |
| 38. | (1),2 | (1),2 | 1,(2) | (1),2 |
| 39. | (1),2,(3) | 1,(2) | 1,(2-3) | 1-2,(3) |
| 40. | (1),2 | 1-2 | 1-2 | (1),2 |
| 41. | 3-4 | (1),2-5 | (1),2-3,(4) | 1-2 |
| 45. | 1-2 | 1-2 | 1-2 | 1,(2) |
| 46. | 1,(2) | 1 | 1 | 1 |
| 47. | (1),2 | 1-2 | 1,(2) | 1,(2) |
| 53. | 1 | 1 | 1 | 1 |
| 54. | 2 | (1),2 | 1-2 | 1-2 |
| 55. | 3-4 | 1-2 | 1,(2),3-4 | 1-2 |
| **Metalarvae** | | | | |
| 28. | 1-2 | 1-2 | 1 | 1 |
| 29. | 1 | 1-2 | 1-2 | 1 |
| 30. | 2 | 2 | 2 | 2 |
| 31. | 3 | 3 | 3 | 3 |
| 32. | 3 | 3 | (2),3 | (1),2-3 |
| 33. | 3 | 3 | (1),2-3 | 1-2 |
| 34. | 1 | 1, (4) | 1 | 1 |
| 38. | 1-2 | 1-2 | 1,(2) | 1,(2) |

(continued)

**Table 62.** Continued.

| Character number | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| 39. | (1),2,(3) | 1 | 1 | 1 |
| 40. | (1),2 | 1-2 | 1-2 | 1,(2) |
| 41. | 3-4 | 1-2,(3-4) | (1),2,(3) | 1,(2) |
| 48. | 1 | 1,(2) | 1,(2) | (1),2 |
| 49. | 1-3 | 1-2,(3) | 1,(2-3) | (1),2 |
| 50. | 1,3 | 1,(3) | 1 | 1-2 |
| 51. | 3 | 3 | 1,(2) | 1,(2) |
| 52. | 1-2 | 1-2 | 1 | 1 |
| 53. | 1 | 1 | 1 | 1 |
| 54. | 1-2 | 1-2 | 1,(2) | 1,(2) |
| **Juveniles** | | | | |
| 28. | (1),2 | (1),2 | 1,(2) | 1 |
| 29. | 1,(2) | (1),2 | 1-2 | 1-2 |
| 30. | 2 | 2 | 2 | 2 |
| 34. | 1 | 1,(3-4) | 1 | 1 |
| 35. | 3 | 3 | 2-3 | 1-3 |
| 36. | 3 | (2),3 | 1-2,(3) | 1-2,(3) |
| 37. | 1 | 1-2 | 1 | 1 |
| 38. | 1,(2) | 1,(2) | 1 | 1,(2) |
| 39. | 1,(2-3) | 1 | 1 | 1,(2) |
| 40. | 1-2 | 1,(2) | 1-2 | 1,(2) |
| 41. | 1,(2-4),NA[obscured] | 1-2,(3) | 1-2,(3) | 1-2 |
| 48. | 1,(2) | 1-2 | (1),2 | 2 |
| 49. | 3 | (1-2),3 | 1,(2-3) | 1-2,(3) |
| 50. | 1,3 | 1 | 1-2 | (1),2 |
| 51. | 3 | 3 | 1-3 | 1-3 |
| 52. | 1-2 | 1-2 | 1 | 1-2 |
| 53. | 1 | 1 | 1 | 1 |
| 54. | 1-2 | 1,(2) | 1 | 1,(2) |

**Key to pigment characters and states** (applicable developmental phases in brackets–pr = protolarvae, fm = flexion mesolarvae, pm = postflexion mesolarvae, mt = metalarvae, ej = early juveniles):

21. Snout [fm-pm]
    1. unpigmented.
    2. pigmented with 1-5 melanophores.
    3. pigmented with 6 or more melanophores.
22. Dorsal surface of head [pr-fm]
    1. unpigmented or pigmented only over hindbrain (posterior to middle of eyes).
    2. pigmented over both mid- and hindbrain (anterior and posterior to middle of eyes).
23. Pigmentation across dorsal surface of body between head and last myomere (for specimens with greater than 12 melanophores on dorsal surface)[pr-pm]
    1. not scattered or sparsely scattered with at least a partial, distinct, lengthwise line or narrow band of melanophores (sometimes in oblique pairs or clusters) on or lateral to dorsal midline.
    2. densely scattered over all or most of back with at least a partial, distinct, lengthwise line or narrow band of melanophores (sometimes in oblique pairs or clusters) on or lateral to dorsal midline.
    3. densely scattered over all or most of back with no distinct, lengthwise lines or narrow bands of melanophores.
24. Dorsal midline from shortly behind head to near last myomeres [pr-pm]
    1. with up to 24 melanophores in a short, well-spaced, or distinctly discontinuous line (two or more well-spaced segments), or without any distinct line of melanophores.
    2. with at least 25 melanophores but in a short or distinctly discontinuous line (two or more well-separated segments).
    3. with at least 25 melanophores in a distinct continuous or nearly continuous full-length line.
25. Pigmentation on dorsal surfaces lateral to midline from shortly behind head to about 2/3 distance to last myomeres [pr-pm]
    1. absent, sparsely scattered, or densely scattered over back with no distinct, lengthwise lines or narrow bands of melanophores along either side of dorsal midline [character 26 NA].
    2. scattered or not, with a distinct, short or discontinuous (well separated segments) line or narrow band of melanophores (sometimes in oblique pairs or clusters) along one or both sides of dorsal midline.
    3. scattered or not, with a distinct, continuous or nearly continuous, full-length line or narrow band of melanophores (sometimes in oblique pairs or clusters) along each side of dorsal midline.

(continued)

**Table 62.** Continued.

26. Melanophores in lines lateral and parallel to dorsal midline between head and 2/3 distance to last myomeres mostly [fm-pm; NA if character 25 is state 1]
    1. in single file.
    2. in obliquely oriented pairs or clusters resulting in a herringbone pattern down the back.
27. Dorsal surface of end of urostyle (uroneural) [pm]
    1. with few to no melanophores (pigmentation not distinctly greater than elsewhere in vicinity).
    2. with a prominent series of melanophores.
28. Pigmentation on dorsal surface of body between head and last myomere [mt-ej]
    1. scattered more or less evenly (with or without emphasis on distinct lines of melanophores or melanophore clusters on or lateral and parallel to dorsal midline).
    2. scattered in a blotchy or mottled pattern (with or without emphasis on distinct lines of melanophores or melanophore clusters on or lateral and parallel to dorsal midline).
29. Distinct spot or aggregation of pigment at origin of dorsal fin [mt-ej]
    1. absent or obscure.
    2. prominent.
30. Pigment on or between pterygiophores of dorsal fin [mt-ej]
    1. absent or not obvious (essentially white).
    2. obvious (light to strong).
31. Lateral surface of head posterior to eyes [fm-mt]
    1. unpigmented.
    2. pigmented with 1-5 melanophores.
    3. pigmented with more than 5 melanophores.
32. Lateral surface of body above horizontal myosepta (lateral midline) and below dorsolateral surface (exclusive of pigmentation associated with horizontal myosepta, air bladder or visceral-cavity peritoneum) [fm-mt]
    1. unpigmented.
    2. pigmented with 1-5 melanophores.
    3. pigmented with more than 5 melanophores.
33. Lateral surface of body below horizontal myosepta (or lateral midline; exclusive of pigmentation associated with horizontal myosepta, air bladder, gut, or visceral-cavity peritoneum) [fm-mt]
    1. unpigmented.
    2. pigmented with 1-5 melanophores.
    3. pigmented with more than 5 melanophores.
34. Mid-lateral surface of body [pigmentation, large spots -- mt-ej]
    1. with no distinct, near-eye-size spots of pigment.
    2. with 1 distinct, near-eye-size spot of pigment on caudal peduncle near base of caudal fin.
    3. with 2 distinct, near-eye-size spots of pigment, one between head and dorsal fin and the other between pelvic and anal fins (sometimes with a very faint or indistinct third near-eye-size spot near the base of the tail).
    4. with 3 distinct, near-eye-size spots of pigment, one between head and dorsal fin, the second between pelvic and anal fins, and the third on the caudal peduncle near the base of the tail.
    5. with 1 or more distinct, near-eye-size spots of pigment, but not as in character states 2-4.
35. Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent (exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity peritoneum, or gut) [ej]
    1. scattered only partially down to the horizontal myoseptum (lateral midline).
    2. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum.
    3. scattered evenly or in mottled pattern (continuous with dorsal and dorsolateral surface pattern) down to horizontal myoseptum and at least partially to bottom-of-eye level below.
36. Pigmentation on lateral to ventrolateral surfaces of body below bottom-of-eye level (exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity peritoneum, or gut) [ej]
    1. absent including caudal peduncle.
    2. absent except on caudal peduncle.
    3. present.
37. Pigmentation outlining scales [presence -- ej]
    1. absent or light.
    2. bold.
38. Melanophores under chin (anterior ventral surface of lower jaw) [pr-ej]
    1. absent.
    2. present.
39. Melanophores on ventral to ventrolateral surfaces of preopercles and opercles (gill covers) [pr-ej]
    1. absent.
    2. present, but not consisting of or including a distinct oblique row of 3 or more melanophores near or along the margin of either preopercle.
    3. consisting of or including a distinct oblique row of 3 or more melanophores near or along the margin of one or both preopercles.
40. Melanophores on ventral surface of heart region [pr-ej]
    1. absent.
    2. present.

(continued)

**Table 62.** Continued.

41. Ventral midline from shortly behind heart region to near vent [pr-ej]
    1. without melanophore pigment.
    2. with 1 to 6 melanophores.
    3. with 7 to 20 melanophores.
    4. with greater than 20 melanophores in a short or a distinctly discontinuous line or narrow band (two or more well-separated segments).
    5. with greater than 20 melanophores in a continuous or nearly continuous full-length line or narrow band.
45. Pigmentation in developing dorsal fin [pm]
    1. absent or sparse with 5 or fewer melanophores.
    2. at least moderate with 6 or more melanophores.
46. Pigmentation in developing anal fin [pm]
    1. absent.
    2. present.
47. Pigmentation in developing pectoral fins [pm]
    1. absent.
    2. present.
48. Pigmentation in dorsal fin [mt-ej]
    1. present to extensive along principal fin rays with few, if any, melanophores on membranes between rays (but might be present on membranes between branches of rays).
    2. extensive along principal fin rays and notably present (more than just a few melanophores) to extensive on at least a portion of membranes between some or all principal rays (might also be present on membranes between branches of rays).
49. Pigmentation in anal fin [mt-ej]
    1. absent.
    2. present but very light with 5 or fewer melanophores.
    3. present but more prominent with 6 or more melanophores.
       (Melanophores are sometimes very linear along margins of fin rays and easily overlooked.)
50. Pigmentation in caudal fin [mt-ej]
    1. present to extensive along principal fin rays with few, if any, melanophores on membranes between principal rays (but might be present on membranes between branches of rays).
    2. extensive along principal fin rays and notably present (more than just a few melanophores) to extensive on most or at least the middle or distal portions of membranes between some or all principal rays (might also be present on membranes between branches of rays).
    3. extensive along principal fin rays and notably present (more than just a few melanophores) to extensive only on proximal portions of membranes between at least some principal rays.
51. Pigmentation in pectoral fins [mt-ej]
    1. absent.
    2. present but very light with up to 5 melanophores.
    3. present but more prominent with greater than 5 melanophores.
52. Pigmentation in pelvic fins [mt-ej]
    1. absent.
    2. present (but seldom with more than a few melanophores).
53. Pigmentation along and in horizontal myosepta [pm-ej]
    1. not notably more intense than other lateral pigmentation or the only lateral pigmentation.
    2. notably more intense than other lateral pigmentation.
54. Melanophores on ventral surface anterior to heart in branchial (gular) region (between opercles or branchiostegal membranes) [all]
    1. absent.
    2. present.
55. Pigmentation over dorsal surface of gut under air bladder as apparent from lateral view [fm-pm]
    1. absent.
    2. present covering less than a quarter of distance.
    3. present covering a quarter to three-quarters of distance.
    4. present covering greater than three-quarters of distance.

**Table 63.** Comparison of size (mm SL) relative to mouth position and lower lip lobe separation for metalarvae (M) and juveniles (J, ≤40 mm SL) of native catostomids of the Gila River Basin. (Size is preceded by initials for the applicable developmental intervals. Rare values are given in parentheses.)

| Character | *Catostomus clarkii* | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|---|
| **Mouth position** | | | | |
| Terminal, above bottom of eye | – | – | – | MJ ≤25 |
| Low terminal, at or below bottom of eye | M ≤17 | M ≤ 23 | MJ all | MJ all |
| Subterminal, low, and not most anterior portion of snout | MJ ≥(16)17 | MJ ≥20 | MJ ≥20 | J ≥32 |
| **Lower lip lobes, median separation** | | | | |
| Indistinct | M ≤17 | M ≤20 | – | – |
| Well separated | M ≥17 | M 21 | M ≤20 | MJ ≤37 |
| Slightly separated | MJ 18-27 | M 21-24 | MJ all | MJ 20-37 |
| None, adjacent | J ≥(23-)28 | MJ ≥22 | MJ ≥22 | MJ ≥20 |

**Table 64.** Comparison of frontoparietal fontanelle size for selected larval and juvenile length groups of native catostomids of the Gila River Basin. (*Catostomus clarkii* not analyzed. N = number of specimens examined.)

| Size group<br>Character | *Catostomus insignis* | *Catostomus latipinnis* | *Xyrauchen texanus* |
|---|---|---|---|
| 17-19 mm SL, N | 1 | 3 | 3 |
| Width, mm | 1.5 | 0.8-1.2 | 1.0-1.2 |
| Length, mm | 1.8 | 1.2-2.0 | 1.7-1.9 |
| Width/length, % | 83 | 50-67 | 59-63 |
| 20-21 mm SL, N | 1 | 3 | 5 |
| Width, mm | 1.8 | 0.6-0.7 | 1.0-1.3 |
| Length, mm | 2.2 | 1.8-2.0 | 1.8-2.1 |
| Width/length, % | 82 | 33-35 | 52-68 |
| 22-25 mm SL, N | 2 | 3 | 2 |
| Width, mm | 0.8-1.6 | 0.8-0.8 | 1.0-1.3 |
| Length, mm | 2.1-2.2 | 1.8-2.1 | 1.9-2.1 |
| Width/length, % | 38-73 | 38-44 | 53-62 |
| 26-34 mm SL, N | 4 | 2 | 2 |
| Width, mm | 0.6-0.9 | 0.7-0.8 | 0.9-1.3 |
| Length, mm | 2.2-2.6 | 2.2-2.3 | 2.1-2.3 |
| Width/length, % | 26-41 | 30-36 | 43-57 |
| 35-46 mm SL, N | – | 1 | 3 |
| Width, mm | – | 0.7 | 1.1-1.7 |
| Length, mm | – | 2.3 | 2.3-3.4 |
| Width/length, % | – | 30 | 48-50 |
| 76-81 mm SL, N | – | 1 | 1 |
| Width, mm | – | 1.0 | 2.3 |
| Length, mm | – | 4.0 | 5.1 |
| Width/length, % | – | 25 | 45 |

## Native Cyprinids

**Table 65.** Comparison of size (mm SL) at onset of or transition to developmental intervals, gut phases, and other developmental events for larvae and early juveniles of native cyprinids of the Gila River Basin. (Rare values in parentheses. NA = not applicable.)

| Character | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| **Egg diameter** | 2.2-2.8 | 2.0-2.4 | 2.7-3.1 | 1.7-2.1 | 1.9-2.2 | 1.8-2.3 | est. 1.6-2.2 |
| **Phase/period transitions** | | | | | | | |
| Embryo to larva | 5(6) | 5-6 | 7(8) | 5 | (5)6-7 | (5)6 | 5-6 |
| Proto- to mesolarva | 7 | (7)8 | (8)9-10 | 7(8) | 7-8(9) | (6)7-8 | 6-7 |
| Flexion to postflexion mesolarva | 9 | (8)9 | 10-11 | 9(-11) | (7)8-9 | 8(9) | 8-9 |
| Meso- to metalarva | 11-12 | 11(12) | 12-13(14) | 12(13) | (10)11-12 | (9)10 | 9-10(11) |
| Larva to juvenile | (15)16(17) | 22(23) | (18)19-20(-22) | (25-)27->41 | 19-20(21) | 14(15) | 15-16(17) |
| **Gut phase transitions** | | | | | | | |
| 1 to 2 (90° bend) | 10-11 | (11)12-15 | 12-14 | 12-18 | 11-17 | 12(-14) | 10-11 |
| 2 to 3 (full loop) | 13-14 | (19)20-22 | 28-34 | (18-)25->41 | 31-38 | >20,<42 | 18-26 |
| 3 to 4 (partial crossover) | (15)16-19(20) | NA | NA | NA,(25) | NA | NA | NA |
| 4 to 5 (full crossover) | (19-)24-25 | NA | NA | NA | NA | NA | NA |
| **Onset of selected events** | | | | | | | |
| Eyes pigmented | 5(6) | 6 [c] | [c] | [c] | [c] | 5(6) [c] | 5? [c] |
| Yolk assimilated | (6)7 | 8-9 | 9-10(11) | (6)7(8) | (7)8(9) | (7)8 | 6-8(9) |
| Finfold absorbed | (15)16(17) | 22(23) | (18)19-20(-22) | (25-)27->41 | 19-20(21) | 14(15) | 15-16(17) |
| Pectoral-fin buds | [c] | 6 [c] | [c] | [c] | 6 [c] | [c] | [c] |
| Pelvic-fin buds | (9)10 | 10-11 [d] | (10)11-12 | 11 | 10-11 | 9 | 9-10 |
| Pelvic fins adnate [a] | NA | NA | NA | 21-22 | NA | NA | NA |
| Dorsal spine formation [b] | NA | NA | NA | (19-)22-24 | NA | NA | NA |
| Maxillary barbels | 19-20(21) | NA | NA | NA | NA | NA | 16-17 |
| **Fin rays first observed** | | | | | | | |
| Dorsal, principal | (8)9(10) | 9 | 10 | 9-10 | 8 | 8(9) | 7-8 |
| Anal, principal | 9-10 | 9 | 10(11) | 10 | 9-10 | 9 | 8 |
| Caudal, principal | 7 | (7)8 | (8)9-10 | 7(8) | 7-8(9) | (6)7-8 | 6-7 |
| Caudal, rudimentary | 9 | 9-10 | (10)11 | 9-10 | (7)8-9(10) | 9(10) | 9-10 |
| Pectoral | (9)10 | 9-10 | 11-13 | 9-10 | 11-12 | 9(10) | 9-10 |
| Pelvic | 12(13) | 10-11 | 12-14 | 13(14) | 11-12 | 11(12) | 11-12 |
| **Full fin-ray counts first observed** | | | | | | | |
| Dorsal, principal | (10)11-12 | 11(12) | (10-)12-13(14) | (11)12 | (10)11-12 | (9)10 | 9-10(11) |
| Anal, principal | 11-12 | 11(12) | 12-13(14) | 12(13) | 11-12 | (9)10 | 9-10(11) |
| Caudal, principal | 9 | (8)9 | 10-11 | 9(-11) | (7)8-9 | 8(9) | 8-9 |
| Caudal, rudimentary | (14)15(16) | <22(23) | 16-19 | (16-)21-24 | 17 | 14 | 15-16 |
| Pectoral | 14(15) | 14 | 14-16 | (15-)18(-21) | 16-17 | (13)14 | 13-15(16) |
| Pelvic | 14-15 | 15 | 14-17 | (14)15(16) | 15 | 13-14 | (12)13-14 |
| **Scales, lateral series** | | | | | | | |
| First observed | 22-25(-31) | ≤25 | ≤24 | NA | ~27-31 | 20-21 | 17-18 |
| Full series first observed | (23-)25(-31) | – | – | NA | 35-40 | 21-24 | 19-24 |

[a] Medial margin of fin at least partially connected to body.
[b] Transformation (thickening and elongation) of second (last) rudimentary to a distinctive spine as indicated by length greater than three-quarters that of the first principal dorsal-fin ray.
[c] (Or) before hatching.
[d] Pelvic-fin bud formation reported as 11 mm SL by Muth (1990); extended range to 10 mm to accommodate Muth's report of first pelvic-fin ray formation at 10-11 mm SL.

**Table 66.** Comparison of selected meristics for larvae and early juveniles of native cyprinids of the Gila River Basin. (Character range is followed by the mean, mode, or more typical range. See Figure 4 for methods of counting myomeres and fin rays. ODF = origin of dorsal finfold, OD = origin of dorsal fin, OP2 = origin of pelvic buds or fins, and PV = posterior margin of the vent. Vertebra counts include four for the Weberian complex; dorsal- and anal-fin-ray counts are of principal rays; scale counts are of the lateral line or series. Data previously published by other authors are given in parentheses; sources are listed in corresponding species accounts.)

| Character | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| **Myomeres to ODF** | | | | | | | |
| Protolarvae | 9-15, 13 | – | 11-12, 12 | 12-17, 15 | 10-17, 16 | 11-16, 14 | 12-15, 14 |
| Flexion mesolarvae | 11-14, 13 | – | – | 16-18, 17 | 17-18, 18 | 12-16, 14 | 13-16, 15 |
| Postflexion mesolarvae | 11-15, 13 | – | – | 16-19, 17 | 15-19, 18 | 12-17, 15 | 14 (N=1) |
| **Myomeres to OD** | | | | | | | |
| Postflexion mesolarvae | 16-18, 17 | 19-21, 20 | 19-21, 20 | 18-20, 19 | 21-25, 23 | 17-19, 18 | 17-21, 18 |
| Metalarvae | 16-18, 17 | 19-22, 20 | 17-20, 19 | 17-19, 18 [a] | 21-24, 23 | 16-20, 18 | 16-20, 19 |
| **Myomeres to OP2** | | | | | | | |
| Postflexion mesolarvae | 15-17, 16 | 17-17 [c] | 15-18, 16 | 16-18, 17 | – | 16-18, 17 | 16-17 [c] |
| Metalarvae | 15-18, 17 | 16-18, 17 | 15-17, 16 | 16-17, 17 [a] | 18-21, 19 | 16-18, 17 | 14-17, 16 |
| **Myomeres to PV** | | | | | | | |
| Proto- & mesolarvae | 24-28, 26-27 | 29-32, 30 | 26-32, 29 | 25-29, 27-28 | 31-35, 33-34 | 23-27, 25-26 | 23-26, 25 |
| Metalarvae | 25-27, 26 | 29-32, 30 | 25-30, 28 | 27-28, 28 [a] | 31-34, 33 | 25-27, 26 | 23-27, 24 |
| All larvae | 24-28, 26-27 | 29-32, 30 | 25-32, 28-29 | 25-29, 27-28 [a] | 31-35, 33-34 | 23-27, 25-26 | 23-27, 24-25 |
| **Myomeres after PV** | | | | | | | |
| Proto- & mesolarvae | 10-14, 11-12 | 19-21, 21 | 13-19, 17-18 | 11-14, 13 | 14-17, 15-17 | 10-12, 10-11 | 10-14, 12-13 |
| Metalarvae | 11-13, 12 | 19-21, 20 | 16-19, 18 | 12-14, 13 [a] | 15-18, 16 | 10-13, 11 | 11-16, 14 |
| All larvae | 10-14, 11-12 | 19-21, 20-21 | 13-19, 17-18 | 11-14, 13 [a] | 14-18, 15-17 | 10-13, 10-11 | 10-16, 12-14 |
| **Myomeres, total** | | | | | | | |
| Proto- & mesolarvae | 36-39, 37-38 | 49-52, 51 | 43-48, 46-47 | 39-42, 40-41 | 48-51, 49-50 | 34-38, 36-37 | 34-40, 37-38 |
| Metalarvae | 37-39, 38 | 49-52, 50 | 44-48, 46 | 40-41, 41 [a] | 48-50, 49 | 36-39, 38 | 36-40, 38 |
| All larvae | 36-39, 37-38 | 49-52, 50-51 | 43-48, 46-47 | 39-42, 40-41 [a] | 48-51, 49-50 | 34-39, 36-38 | 34-40, 37-38 |
| **Vertebrae** | 38<br>– | 49-51, 50<br>(46-51, 49) | 44-47, 46<br>(42-49, 46) | 39<br>(39-42, 40) | 47-49, 48-49<br>(47-49, 48-49) | 38<br>– | 38-40<br>(37-38) |
| **Dorsal-fin rays** | 7-9, 8<br>(7-10, 8) | 10-11, 10<br>(9-11, 10) | 9<br>(8-10, 9) | 7 [b]<br>(7-8, 7) | 9-10, 9<br>(9-10, 9) | 8<br>(8-9, 8) | 7-8, 8<br>(6-9, 8) |
| **Anal-fin rays** | 7<br>(6-8, 7) | 10-11, 10<br>(9-11, 10) | 8-10, 9<br>(7-10, 9) | 8-10, 9<br>(8-10, 9) | 8-10, 9<br>(8-10, 9) | 6-7, 7<br>(6-7, 7) | 6-8, 7<br>(6-8, 7) |
| **Lateral-line scales** | 77-93, 81-93<br>(60-95, 73-90) | –<br>(75-110, 88-99) | –<br>(71-99, 79-86) | not applicable | –<br>(76-98, 84-93) | 65-73, 65-71<br>(61-70, 61-65) | –<br>(47-90, 55-80) |

[a] Metalarvae > 25 mm SL excluded.

[b] First principal dorsal-fin ray preceded and partially enveloped by a slightly shorter, stout spine which is derived from a rudimentary (secondary) ray and well formed by transition to the juvenile period resulting in dorsal fin formula of I,7 or i,I,7 (lower-case Roman numerals refer to normal rudimentary rays, in this case a very tiny splint at or incorporated in the anterior base of the spine). The first principal dorsal-fin ray sometimes has itself been considered as second spine in adults, which would result in a formula of II,6 or i,II,6.

[c] N = 2.

**Table 67.** Comparison of the more diagnostic differences in morphometrics for larvae and juveniles (≤40 mm SL) of native cyprinids of the Gila River Basin. (Except as indicated, all data are percentages of standard length, % SL, presented as ranges followed by means. HL = head length measured to the origin of the pectoral fin, AS to OP1; see Figure 4 for other abbreviations and methods of measurement.)

| Developmental Phase<br>Character | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| **Protolarvae** | | | | | | | |
| Eye diameter [a] | 7-9, 8 | 5-7, 6 | 5-7, 6 | 6-8, 7 | 6-8, 7 | 6-9, 7 | 6-9, 8 |
| AS-to-PE length | 9-12, 10 | 7-10, 9 | 8-11, 9 | 9-11, 10 | 8-11, 9 | 8-12, 10 | 8-12, 10 |
| AS-to-ODF length | 31-44, 40 | 39-42 | 26-39 | 42-46, 44 | 32-44, 42 | 40-48, 44 | 41-45, 43 |
| AS-to-PV length | 64-68, 66 | 62-70, 65 | 67-72, 69 | 64-68, 65 | 67-69, 68 | 64-71, 67 | 63-69, 66 |
| Yolk length [b] | 0-50, 29 | – | 49-62 | 0-56, 37 | 42-55, 49 | 33-56, 47 | 0-56, 39 |
| Pectoral-fin length [c] | 10-14, 12 | 4-12 | 4-10 | 9-15, 13 | 4-10, 7 | 5-13, 9 | 6-12, 9 |
| Depth at OD [b] | 10-14, 11 | 9-15, 12 | 13-15, 14 | 10-17, 12 | 12-15, 14 | 11-19, 15 | 10-16, 13 |
| Width at OD [b] | 5-7, 6 | 5-8, 6 | 7-8, 8 | 5-9, 6 | 5-10, 7 | 6-10, 8 | 5-9, 7 |
| Max. yolk depth [b] | 0-13, 5 | – | 10-18 | 0-20, 9 | 9-15, 13 | 2-17, 11 | 0-16, 8 |
| Max. yolk width [b] | 0-12, 7 | – | 12-23 | 0-22, 11 | 9-18, 12 | 3-23, 13 | 0-20, 10 |
| **Flexion mesolarvae** | | | | | | | |
| Eye diameter, % HL [a] | 34-47, 37 | 24-33, 29 | 27-36, 32 | 32-36, 34 | 34-37, 36 | 33-41, 35 | 36-40, 38 |
| AS-to-PE length | 10-12, 11 | 8-10, 9 | 9-12, 11 | 10-12, 11 | 10-10, 10 | 10-12, 11 | 11-13, 12 |
| AS-to-OPAF length | 25-33, 30 | 29-32 | 28-37 | 27-32, 30 | 25-28, 27 | 27-39, 32 | 30-44, 36 |
| AS-to-ODF length | 37-47, 42 | 42-45 | 40-48 | 43-48, 46 | 44-45, 45 | 37-48, 43 | 37-55, 47 |
| AS-to-PV length | 66-70, 68 | 63-70, 67 | 65-71, 68 | 64-69, 66 | 67-68, 67 | 63-70, 67 | 63-70, 66 |
| Yolk length | 0 | 0-26 | 0-45 | 0-13, 1 | 0-48, 23 | 0-42, 21 | 0-43, 9 |
| Pectoral-fin length | 12-16, 14 | 12-13 | 10-13 | 12-15, 14 | 11-12, 12 | 12-16, 13 | 12-14, 13 |
| Depth at OP1 | 15-17, 16 | 12-17, 14 | 12-18, 16 | 13-17, 15 | 13-14, 13 | 14-18, 16 | 12-18, 14 |
| Depth at OD [d] | 11-13, 12 | 8-14, 11 | 10-16, 12 | 9-13, 11 | 11-11, 11 | 11-14, 13 | 10-13, 11 |
| Depth at BPV | 7-9, 8 | 6-9, 8 | 8-11, 9 | 7-8, 8 | 8-8, 8 | 9-10, 9 | 8-10, 9 |
| Width at BPE | 13-17, 15 | 11-14, 13 | 10-14, 13 | 14-16, 15 | 12-13, 12 | 13-16, 15 | 13-14, 13 |
| Width at OP1 | 10-12, 11 | 7-11, 10 | 10-13, 11 | 9-14, 12 | 9-10, 10 | 11-14, 11 | 8-14, 10 |
| Width at OD [d] | 6-7, 6 | 4-7, 5 | 6-9, 7 | 5-7, 6 | 6-6, 6 | 6-8, 7 | 6-8, 7 |
| Max. yolk depth | 0 | 0-4 | 0-9 | 0-1, 0 | 0-8, 3 | 0-8, 2 | 0-6, 1 |
| Max. yolk width | 0 | 0-8 | 0-9 | 0-2, 0 | 0-11, 6 | 0-12, 4 | 0-10, 2 |
| **Postflexion mesolarvae** | | | | | | | |
| Eye diameter, % HL [a] | 30-46, 34 | 27-36 | 29-38, 33 | 30-37, 33 | 22-37, 33 | 31-36, 33 | 31-38, 34 |
| AS-to-OP1 length | 20-26, 24 | 22-24, 22 | 22-26, 24 | 20-24, 22 | 20-25, 22 | 20-26, 23 | 22-27, 24 |
| AS-to-OP2 length | 48-52, 49 | 44-46 | 45-50, 47 | 46-50, 48 | – | 49-51, 50 | 48-51, 49 |
| AS-to-OPAF length | 31-39, 34 | 29-31 | 33-41 | 28-35, 32 | 27-34, 29 | 28-40, 33 | 30-53, 41 |
| AS-to-PV length | 69-74, 71 | 66-69, 67 | 67-72, 70 | 66-71, 69 | 67-74, 70 | 67-72, 70 | 65-71, 68 |
| Yolk length | 0 | 0 | 0-32 | 0 | 0 | 0 | 0 |
| Pectoral-fin length | 13-21, 15 | 12-13 | 12-14 | 13-16, 14 | 11-15, 13 | 12-16, 15 | 11-15, 13 |
| Dorsal-fin-base length [e,f] | 10-14, 12 | – | 10-12, 11 | 9-13, 11 | – | 10-13, 11 | 8-16, 11 |
| Depth at OP1 | 16-21, 19 | 12-17, 14 | 12-18, 16 | 16-18, 17 | 13-17, 14 | 16-19, 18 | 15-21, 17 |
| Depth at OD | 12-16, 14 | 8-14, 11 | 10-16, 12 | 11-14, 12 | 10-14, 11 | 13-15, 14 | 12-15, 13 |
| Depth at BPV | 8-11, 10 | 6-9, 8 | 8-11, 9 | 7-10, 9 | 7-10, 8 | 9-11, 10 | 9-12, 10 |
| Width at BPE | 14-19, 17 | 13-14, 13 | 14-16, 15 | 15-17, 16 | 13-14, 13 | 16-17, 16 | 14-16, 15 |
| Width at OP1 | 12-16, 14 | 7-11, 10 | 10-13, 11 | 13-17, 15 | 9-12, 10 | 13-17, 14 | 10-18, 12 |
| Width at OD | 7-11, 9 | 4-7, 5 | 6-9, 7 | 6-9, 8 | 5-8, 6 | 7-8, 7 | 6-9, 7 |
| Max. yolk depth | 0 | 0 | 0-2 | 0 | 0 | 0 | 0 |
| Max. yolk width | 0 | 0 | 0-9 | 0 | 0 | 0 | 0 |
| **Metalarvae** | | | | **< 25 mm SL [h]** | | | |
| Eye diameter, % HL [a] | 28-35, 32 | 28-36, 32 | 21-29, 25 | 26-36, 31 | 25-32, 29 | 24-34, 28 | 26-38, 33 |
| AS-to-AE length | 4-6, 5 | 3-6, 4 | 4-9, 6 | 4-7, 6 | 5-9, 6 | 4-8, 6 | 4-6, 5 |
| AS-to-PE length | 12-14, 13 | 11-14, 12 | 11-16, 13 | 12-14, 13 | 12-18, 14 | 11-15, 13 | 11-15, 13 |
| AS-to-OP1 length | 24-27, 26 | 23-28, 25 | 23-31, 28 | 22-26, 23 | 24-29, 26 | 23-28, 26 | 23-28, 25 |
| AS-to-OP2 length | 48-54, 52 | 44-49, 47 | 47-54, 51 | 47-50, 48 | 49-54, 52 | 49-54, 51 | 48-54, 51 |
| AS-to-OD length | 49-54, 51 | 50-57, 52 | 51-58, 55 | 49-53, 50 | 51-57, 55 | 50-54, 52 | 51-58, 55 |
| AS-to-ID length | 63-67, 65 | 62-69, 65 | 63-69, 66 | 63-66, 64 | 63-68, 66 | 63-69, 65 | 65-70, 67 |
| AS-to-PV length | 68-71, 69 | 62-70, 65 | 63-73, 68 | 64-70, 67 | 65-69, 68 | 68-73, 69 | 63-69, 65 |
| AS-to-IA length | 76-80, 78 | 75-82, 77 | 75-81, 78 | 76-79, 78 | 75-82, 79 | 75-79, 77 | 72-77, 75 |

(continued)

**Table 67.** Continued.

| Developmental Phase<br>Character | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| Caudal-fin length [g] | 15-21, 18 | 16-26, 23 | 16-28, 23 | 16-22, 19 | 20-30, 24 | 15-22, 19 | 14-24, 19 |
| Pectoral-fin length | 14-18, 16 | 12-15, 14 | 12-17, 15 | 14-18, 16 | 13-16, 15 | 15-20, 18 | 11-18, 14 |
| Pelvic-fin length | 5-13, 9 | 5-16, 10 | 3-13, 6 | 4-12, 9 | 7-14, 10 | 4-17, 10 | 2-13, 7 |
| Dorsal-fin-base length [f] | 11-17, 14 | 11-15, 13 | 10-12, 11 | 12-16, 14 | 10-12, 11 | 11-15, 13 | 9-17, 11 |
| Depth at BPE | 17-20, 18 | 15-17, 16 | 14-18, 16 | 13-16, 15 | 14-18, 16 | 15-18, 17 | 15-18, 17 |
| Depth at OP1 | 20-25, 22 | 16-24, 20 | 17-22, 20 | 17-20, 19 | 16-19, 18 | 17-22, 20 | 15-23, 20 |
| Depth at OD | 15-25, 20 | 9-24, 19 | 13-21, 17 | 12-19, 16 | 15-18, 16 | 13-20, 16 | 13-21, 17 |
| Depth at BPV | 11-14, 12 | 9-18, 14 | 10-15, 13 | 9-13, 11 | 11-15, 13 | 10-14, 12 | 10-16, 13 |
| Depth at AMPM | 8-10, 9 | 6-7, 7 | 6-9, 7 | 7-9, 8 | 7-9, 8 | 7-10, 9 | 6-10, 8 |
| Width at BPE | 16-19, 18 | 14-16, 15 | 13-19, 16 | 15-18, 16 | 13-16, 15 | 17-20, 18 | 15-19, 17 |
| Width at OP1 | 15-20, 17 | 14-18, 16 | 12-17, 14 | 15-18, 17 | 10-15, 13 | 13-20, 17 | 12-18, 14 |
| Width at OD | 9-17, 13 | 7-18, 12 | 8-13, 10 | 9-14, 11 | 8-12, 10 | 8-13, 10 | 7-13, 10 |
| Width at BPV | 7-9, 8 | 6-13, 10 | 6-11, 8 | 6-10, 8 | 7-11, 8 | 6-9, 7 | 6-11, 9 |
| Width at AMPM | 4-5, 5 | 2-4, 3 | 2-5, 4 | 3-5, 4 | 3-5, 4 | 3-5, 4 | 2-5, 4 |
| **Juveniles <40 mm SL** | | | | **& metalarvae 25-39 mm SL [h]** | | | |
| Eye diameter, % HL [a] | 25-32, 28 | 25-33, 29 | 26-33, 30 | 29-35, 32 | 23-31, 27 | 20-27, 25 | 25-33, 29 |
| AS-to-AE length | 4-8, 6 | 5-6, 5 | 5-8, 6 | 4-7, 6 | 5-8, 6 | 7-9, 8 | 4-8, 6 |
| AS-to-PE length | 11-15, 14 | 11-13, 12 | 12-16, 14 | 12-15, 14 | 12-16, 14 | 13-15, 14 | 11-15, 13 |
| AS-to-OP1 length | 23-28, 26 | 22-26, 24 | 24-29, 27 | 21-26, 24 | 24-30, 26 | 24-28, 26 | 21-28, 24 |
| AS-to-OP2 length | 50-54, 52 | 44-47, 45 | 46-52, 50 | 45-50, 48 | 49-54, 52 | 50-55, 53 | 45-53, 50 |
| AS-to-OD length | 49-53, 51 | 49-54, 51 | 49-57, 54 | 48-52, 50 | 53-56, 55 | 52–55, 53 | 50-57, 53 |
| AS-to-ID length | 63-66, 65 | 62-66, 65 | 61-69, 66 | 63-68, 65 | 63-68, 66 | 64-68, 67 | 62-69, 65 |
| AS-to-PV length | 67-71, 69 | 60-65, 63 | 61-68, 66 | 64-69, 65 | 64-69, 67 | 66-71, 68 | 57-65, 63 |
| AS-to-IA length | 76-79, 77 | 74-78, 76 | 74-80, 77 | 76-80, 78 | 76-82, 79 | 75-80, 77 | 70-77, 73 |
| AS-to-AFC length | 111-115, 113 | 111-114, 112 | 109-116, 115 | 112-117, 114 | 110-116, 113 | 113-119, 116 | 109-115, 112 |
| Caudal-fin length [g] | 18-24, 20 | 23-28, 25 | 18-29, 26 | 19-26, 22 | 22-34, 28 | 18-27, 22 | 17-26, 21 |
| Pectoral-fin length | 16-21, 18 | 15-19, 17 | 14-20, 17 | 15-21, 19 | 13-18, 16 | 18-23, 21 | 14-20, 17 |
| Pelvic-fin length | 11-24, 15 | 15-18, 16 | 9-15, 12 | 12-15, 14 | 11-17, 15 | 11-19, 16 | 10-16, 13 |
| Dorsal-fin length | 20-27, 22 | 20-24, 22 | 18-24, 20 | 19-26, 22 | 18-25, 22 | 21-25, 23 | 18-24, 21 |
| Anal-fin length | 15-22, 18 | 17-23, 21 | 16-21, 18 | 17-21, 19 | 15-20, 18 | 17-23, 21 | 16-22, 19 |
| Dorsal-fin-base length [f] | 11-16, 14 | 12-15, 14 | 11-13, 12 | 13-18, 14 | 10-14, 11 | 12-15, 14 | 10-14, 12 |
| Depth at BPE | 16-20, 18 | 15-17, 16 | 14-19, 17 | 13-16, 14 | 13-16, 15 | 12-18, 15 | 13-18, 16 |
| Depth at OP1 | 21-25, 23 | 20-24, 22 | 19-23, 20 | 16-20, 18 | 17-20, 18 | 16-22, 19 | 18-24, 21 |
| Depth at OD | 18-25, 22 | 20-26, 23 | 18-22, 20 | 16-22, 18 | 17-21, 19 | 16-22, 18 | 18-23, 20 |
| Depth at BPV | 12-17, 14 | 11-15, 13 | 13-18, 15 | 12-14, 14 | 14-17, 15 | 11-17, 13 | 13-19, 16 |
| Depth at AMPM | 9-11, 10 | 6-7, 6 | 7-10, 8 | 7-8, 8 | 8-9, 9 | 9-11, 10 | 9-12, 10 |
| Width at BPE | 15-19, 17 | 14-16, 15 | 13-18, 16 | 13-17, 15 | 13-16, 14 | 13-20, 16 | 12-18, 15 |
| Width at OP1 | 15-20, 18 | 16-21, 18 | 13-17, 14 | 14-16, 15 | 13-17, 15 | 15-21, 18 | 13-21, 16 |
| Width at OD | 12-20, 15 | 15-21, 17 | 10-15, 12 | 11-16, 13 | 10-16, 13 | 10-16, 13 | 11-18, 14 |
| Width at BPV | 8-14, 10 | 11-15, 13 | 8-12, 10 | 8-11, 9 | 8-14, 11 | 7-11, 9 | 9-16, 12 |
| Width at AMPM | 4-6, 5 | 3-4, 4 | 2-5, 4 | 3-5, 4 | 2-5, 4 | 4-5, 4 | 3-7, 6 |

[a] Eye diameter = (AS to PE)-(AS to AE); approximated for *Gila* species by difference between mean, minimum and maximum values in species accounts with range extended by the greater standard deviation, and then, for all but protolarvae, dividing those results by HL.

[b] Ignore differences in maximum values because they may be affected by developmental state at hatching.

[c] Ignore differences in minimum values because they may be affected by developmental state at hatching.

[d] OD for protolarvae and early flexion mesolarvae is approximated at one-half of standard length (AS to PHP).

[e] Applicable only to specimens with a full complement of dorsal-fin pterygiophores or principal rays.

[f] Dorsal-fin base = (AS to ID)-(AS to OD); approximated for *Gila* species by difference between mean, minimum and maximum values in species accounts with range extended by the greater standard deviation.

[g] Caudal-fin length = (AS to PC)-(AS to PHP), total length minus standard length.

[h] Some *Meda fulgida* measuring well beyond 25 mm SL retain preanal finfold and thereby remain metalarvae at size for which most other cyprinids are defined as juveniles. Accordingly, for comparative purposes, morphometric data for metalarvae of this species greater than 24 mm SL are included with data for juveniles.

**Table 68.** Comparison of size (mm SL) relative to melanophore pigmentation of the eyes and bodies for protolarvae and lateral to ventral peritoneum for metalarvae (M) and early juveniles (J, ≤40 mm SL) of native cyprinids of the Gila River Basin. (For peritoneal pigmentation, size is preceded by initials for the applicable developmental intervals. Rare values are given in parentheses.)

| Character | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| **Eye pigmentation, protolarvae** | | | | | | | |
| Unpigmented | 5(6) | 6 [a] | [a] | [a] | [a] | 5(6) [a] | 5? [a] |
| Light to moderate | 5-6 | 6 [a] | 7-9 [a] | 5 [a] | 6?-7 [a] | 5-7(8) [a] | 5? [a] |
| Dark | ≥5? or 6 | ≥7 | ≥9 | ≥5 [a] | ≥6? or 7 [a] | ≥6 | ≥5? [a] or 6 |
| **Body pigmentation, protolarvae** | | | | | | | |
| Unpigmented | 5(6) | 5-7 | 7-8 | [a] | 7 [a] | 5(6) [a] | 5? [a] |
| 1-12 melanophores on dorsum | 5(6) | 7 | 8 | [a] | 7(-9) | 5(6) [a] | 5? [a] |
| ≥13 melanophores on dorsum | ≥(5)6 | ≥(7)8 | ≥(8)9 | ≥5 [a] | ≥7 [a] | ≥(5)6 | ≥5? [a] or 6 |
| **Peritoneal pigmentation** [b] | | | | | | | |
| Lateral | | | | | | | |
| Absent | – | – | – | – | – | MJ (12-)≥16 | – |
| Sparse or patchy | MJ ≤24 | M all | M all | MJ all | M all | MJ ≤16 [c] | MJ≤17(-23) |
| Uniformly speckled | – | M all | – | MJ ≤24(-40) | – | – | – |
| Uniformly light | MJ 15-25(-31) | – | – | – | – | – | – |
| Uniformly dark | MJ (17-)≥22 | – | – | – | – | – | – |
| Obscured by overlying tissues | (J ≥38) | MJ ≥20 | MJ ≥18 | MJ ≥25 | MJ ≥21 | J ≥21 | J ≥20 |
| Ventrolateral surfaces | | | | | | | |
| Absent | MJ ≤14(-19) | – | MJ ≤24 | – | MJ ≤21(23?) | MJ all | MJ≤17(all?) |
| Sparse or patchy | MJ 12-25 | MJ ≤23 | – | MJ all | – | (M 12) [c] | – |
| Uniformly light | (MJ 17-31) | – | – | – | – | – | – |
| Uniformly dark | J ≥22 | – | – | – | – | – | – |
| Obscured by overlying tissues | (J ≥38) | MJ ≥22 | J ≥25 | MJ ≥25 | J ≥24 | – | J ≥20 |
| Ventral surface | | | | | | | |
| Absent | MJ ≤24(-38) | MJ ≤ 32 | MJ ≤34 | M ≤25 | MJ all | MJ all | MJ≤24(all?) |
| Sparse or patchy | MJ 14-27(-36) | – | – | MJ all | – | – | – |
| Uniformly light | J (22-)≥24 | – | – | – | – | – | – |
| Uniformly dark | (J ≥33) | – | – | – | – | – | – |
| Obscured by overlying tissues | – | J ≥ 33 | J ≥35 | MJ ≥25 | – | – | J ≥28 |

[a] (Or) before hatching.

[b] Pigmentation of the peritoneum is subsurface and should not be confused with surface or cutaneous pigmentation; some near-surface pigmentation in protolarvae and mesolarvae becomes distinguishable as peritoneal pigment in metalarvae. Also, pigment is usually apparent in the dorsal and dorsolateral aspects of the peritoneum of smaller metalarvae (and earlier larvae) and should not be interpreted as pigment in the lateral region. In juveniles (and the larger metalarvae of *Meda*), possibly including specimens smaller than recorded, melanophore pigmentation in the peritoneum may be obscured by overlying muscle or, especially in living and alcohol-preserved specimens, integument with a silvery lining of iridophores.

[c] In many metalarvae of this species, lateral peritoneal pigment begins as a broad, internal band of rather larger melanophores below or after the air bladder that continues over the lateral (to ventrolateral) surface of the posterior gut (only rarely does the band begin on the ventrolateral aspect of the peritoneum).

**Table 69.** Comparison of selected melanophore pigmentation patterns for larvae and juveniles (≤40 SL) of native cyprinids of the Gila River Basin. (Key to characters and their states is given below; character numbers correspond to those used in the computer-interactive key. Rare character states are enclosed in parentheses. NA = not applicable.)

| Character number | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| **Protolarvae (after pigment is well established)** | | | | | | | |
| 25. | (1),2,(3),4 | 1 | 1 | (1),2-4 | 1 | 1,(3) | 1 |
| 26. | 2 | 1 | 1 | 2 | 1 | (1),2 | 2 |
| 27. | (1),2-3 | 1 | 1 | 2-3 | 1 | (2),3 | 2 |
| 28. | NA,2-3 | 2 | 1 | NA,(3,5) | 1 | NA,(4) | 3 |
| 29. | NA,2-3,(4) | 3 | 3 | NA,2 | 3 | NA,(2) | 3 |
| 35. | 1-3 | 1 | 2 | (1),2-3 | 1-2 | 1-2 | 1,3 |
| 38. | (1),2,(3),5 | 1-2 | 2 | (1),2,4,(5) | 1,4 | 1,(4),5 | 2,4 |
| 39. | (1,3),6 | 6 | 6 | 3,6 | 1,3,6 | 1,6 | 3,6 |
| 43. | (1),3,(4) | 1 | 1-2 | 3,(4-5) | 1-2 | 1,(2-3) | 1-2 |
| 51. | 1,(2) | 1 | 1 | 1 | 1 | 1 | 1 |
| 52. | 1-2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 53. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 54. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 55. | (1),2,(3),4 | 1-2 | 1-2 | 1,3,(4-5) | 1-2 | 1,(2-4) | 1,3-4 |
| 56. | 1-2,(3) | 2 | 1 | 1,(2-3,6) | 1 | 1-2 | 1 |
| 57. | NA,1,(2-3) | 1 | NA | NA,(1-3) | NA | NA,1 | NA |
| 58. | NA,(2) | NA | NA | NA,(2,6) | NA | NA | NA |
| 59. | NA | NA | NA | NA,(4) | NA | NA | NA |
| **Flexion mesolarvae** | | | | | | | |
| 24. | (1),2-3 | 1-3 | 1-3 | 3 | 1 | 1-3 | 1-3 |
| 25. | 3-4 | 1-2 | 1-2 | (2),3 | 1-2 | 1-2 | 1-2 |
| 26. | 2 | 1-2 | 2 | 2 | 1-2 | 2 | 2 |
| 27. | (1),2-3 | 1 | 1 | 2-3 | 1 | (1-2),3 | 1-2 |
| 28. | NA,(2),3,(4) | 1,3 | 2-3 | NA,5 | 1,3 | NA,(1) | 2-3 |
| 29. | NA,2-3,(4) | 1,3 | 3-4 | NA,2 | 3-4 | NA,(3-4) | 3-4 |
| 35. | 2-3 | 2-3,5 | 2-3 | 2-3 | 2,4 | 1-2 | 2,(3) |
| 37. | 2-3 | 1-3 | 1-3 | (2),3 | 1 | 2-3 | (1),2 |
| 38. | 5 | 2,4 | 3-4 | (2),4 | 2,4 | (1,4),5 | 4-5 |
| 39. | 6 | 6 | 6 | 6 | 1,6 | 6 | 6 |
| 40. | (1),2,(3) | 1 | 1 | (1),2-3 | 1-2 | 1,(2) | (1),2 |
| 41. | 2-3 | 1 | 1-2 | (2),3 | 1 | (1),2-3 | 3 |
| 42. | 2-3 | 1 | 1-2 | (2),3 | 1 | (1),2,(3) | 2-3 |
| 43. | 3-4 | 1-2,5 | 2-3 | 3-4 | 2 | 1-3 | (1),2,(3) |
| 44. | 1 | 1-2 | 1-3 | 1-2,(3) | 1-2 | 1,(2) | 1 |
| 51. | 1,(2) | 1 | 1 | 1 | 1 | 1 | 1 |
| 52. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 53. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 54. | 1-2 | 1 | 1 | 1-2 | 1 | 1 | 1 |
| 55. | 2-3,(4-5) | 2-3 | 2-3 | 4,(5) | 1-3 | (2),3,(4) | 2-3 |
| 56. | 1-3 | 1-2 | 1-2 | (1),2 | 1 | 1 | 1 |
| 57. | NA,(1),3 | NA,1 | NA,1 | (NA),1 | NA | NA | NA |
| 58. | NA,6 | NA | NA | NA | NA | NA | NA |
| 59. | NA | NA | NA | NA | NA | NA | NA |
| **Postflexion mesolarvae** | | | | | | | |
| 24. | (2),3 | 3 | (1),3 | 3 | 3 | 2-3 | 2-3 |
| 25. | (2-3),4 | 1-2 | 1-2 | 3 | 1-2,4 | 3 | 2 |
| 27. | (1),2,(3) | 1 | 1-2 | 2-3 | 1-2 | 3 | 2-3 |
| 28. | (NA,2),3-5 | 2-3 | 3 | NA,5 | 3,5 | NA | NA,2 |
| 29. | (NA),2,(3-4) | 3-4 | 4 | NA,2 | 3-4 | NA | NA,3 |
| 35. | 1-2,(3) | 1-2 | 1-2,(3) | 2-3 | 2,4 | 1 | 1-2 |
| 37. | (2),3 | 2-3 | 2-3 | 3 | 2-3 | 3 | 2-3 |
| 38. | 5 | 4 | 4 | (2),4 | 4 | (4),5 | 4 |
| 39. | 1,6-7 | 4,6-7 | 6 | 6-7 | 3,6 | 6 | 1,6 |
| 40. | 1-2 | 1-2 | 1-2 | 2-3 | 1,3 | 1-2 | 2 |
| 41. | 3 | 1-2 | 1-2,(3) | 3 | 1,3 | 3 | 3 |

(continued)

**Table 69.** Continued.

| Character number | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| 42. | 2-3 | 1 | 1,(2-3) | 3 | 1,3 | 2-3 | 2-3 |
| 43. | 3-4 | 5-6 | (1),2,(3),5 | 3-4 | 1,5 | 2-3 | 2-3,5 |
| 44. | 1 | 1-3 | 2-3 | 1-2,(3) | 3 | 1 | 1-2 |
| 51. | 1-2 | 1 | 1 | 1,(2) | 1-2 | 1 | 1 |
| 52. | 1,(2) | 1 | 1 | 1,(2) | 1-2 | 1 | 1 |
| 53. | 1-2 | 1 | 1 | 1-2 | 1-2 | 1 | 1 |
| 54. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 55. | 1,(2) | 1-3 | 1-2,(3) | 4 | 1-2 | 1-2 | 1,5 |
| 56. | (1),2-3 | 1-2 | 1,(2) | 1-2 | 1 | 1 | 1 |
| 57. | NA,1-2,(3) | NA,1 | NA,(1) | NA,(1),2,(3) | NA | NA | NA |
| 58. | NA,(2,6) | NA | NA | NA | NA | NA | NA |
| 59. | NA | NA | NA | NA | NA | NA | NA |
| 63. | 1-3 | 1-2 | 1,3 | 1-3 | 1,3 | 1,(2-3) | 1,3 |
| 64. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 65. | 1 | 1-2 | 1-2 | (1),2 | 1 | 1,(2) | 1-2 |
| **Metalarvae** | | | | **≤ 25 mm SL** | | | |
| 30. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 31. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 32. | 2-3 | 2 | 1-2,4 | 1-2 | 1-2 | (1),2,4 | 2-4 |
| 33. | 4-5 | 5-6 | 1,5-6 | 5 | 5 | 5 | 1,3 |
| 34. | (3),4-5 | 5 | 5 | 5 | 5 | (1),5 | 3-4 |
| 36. | 1 | 1 | 1 | 1 | 1 | 1 | 1-2 |
| 37. | 3 | 3 | 3 | 3 | 2-3 | 3 | 3 |
| 38. | 4-5 | 4 | 4 | 4 | 4-5 | (1),4,(5) | 4 |
| 41. | 3 | 2-3 | 1,3 | (2),3 | 1,3 | 3 | 3 |
| 42. | 3 | 1-3 | 1,3 | (2),3 | 1-3 | (2),3 | 3 |
| 44. | 1 | 2-3 | 1-3 | 1-3 | 2-3 | 1 | 1 |
| 45. | 1-2,(3) | 1-2 | 1 | 1-2,(3) | 1-3 | 1-2,(3) | 1-3 |
| 46. | 1 | 1 | 1 | 1-2 | 1 | 1 | 1 |
| 47. | 1-2,(3) | 1 | 1 | 1-2,(3) | 1 | 1,3 | 1,3,5 |
| 51. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 52. | 1,(2) | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 53. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 54. | 1-2 | 1 | 1 | 1,(2) | 1 | 1 | 1-2 |
| 55. | 1 | 1 | 1 | 1,(3),4 | 1 | 1 | 1,5 |
| 56. | 1-3 | 1-2 | 1 | 1-2,(3) | 1 | 1,(2) | 1 |
| 57. | NA,(2),3 | NA,1,3 | NA | NA,(1-3) | NA | NA,(3) | NA |
| 58. | NA,(2),6 | NA | NA | NA,(6) | NA | NA | NA |
| 66. | 1 | 1 | 1 | 1,(2) | 1 | 1 | 1 |
| 67. | (1-2),3 | 1,3 | 1-2 | 1,(2),3 | 1,3 | 1,(2-3) | 1-3 |
| 68. | 1,5 | 1-2 | 1 | 1,(2),5 | 1-2 | 5 | 1,5 |
| 69. | (1),2-3 | 1-3 | 1-3 | (1),3 | 1-3 | 1-3 | 1-3 |
| 70. | 1,(2) | 1-2 | 1 | 1 | 1-2 | 1 | 1 |
| **Juveniles** | | | | **(& metalarvae 25-40 mm SL)** | | | |
| 30. | 1 | 1 | 1 | 1-2 | 1 | 1 | 1 |
| 31. | 1,(2) | 1 | 1 | 1 | 1 | 1,(2) | 1 |
| 32. | 3 | 2 | 2 | 2 | 2 | 4 | 3-4 |
| 33. | 4 | 5 | 5 | 5 | 5 | 5 | 3,5 |
| 34. | (3),4,6 | 1,5 | 1,3,5-6 | 1,(2),5 | 5 | 3,5 | 3-4 |
| 36. | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 45. | (2),3 | 1 | 1-2 | 2-3 | 2-3 | 2-3 | 1,3 |
| 46. | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 47. | (1),2-3 | 1-2 | 1-2 | 2,5 | 1 | 1-3 | 4-5 |
| 48. | 2-3 | 3 | 3 | 2-3 | 3 | 3 | 2-3 |
| 49. | 1-2,(3) | 1,3 | 1,3 | (2),3 | 1,3 | (1),3 | 2-3 |
| 50. | 1,(2-4) | 1-2 | 1 | 1 | 1,3 | 1-2 | 1 |
| 51. | 1,(2) | 1 | 1 | 1 | 2 | 1 | 1 |
| 52. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 53. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

(continued)

**Table 69.** Continued.

| Character number | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| 54. | 1-2 | 1 | 1-2 | 1 | 1 | 1 | 1-2 |
| 55. | 1 | 1 | 1,5 | 1 | 1 | 1 | 1,5 |
| 56. | 1-3 | 1-2 | 1 | 1,(3) | 1 | 1 | 1 |
| 57. | NA,(1,3) | NA,3 | NA | NA | NA | NA | NA |
| 58. | NA,(2,6) | NA | NA | NA,(6) | NA | NA | NA |
| 66. | 1-2 | 1 | 1 | 1-2 | 1 | 1-2 | 1 |
| 67. | 1-3 | 3 | 1-3 | 1,(3) | 3 | 1,(2),3 | 1 |
| 68. | 5 | 1 | 1 | 5 | 1 | 5 | 5 |
| 69. | (1-2),3 | 3 | 1-3 | 1,(2),3 | 3 | 1,3 | 1,3 |
| 70. | 1-2 | 1-2 | 1 | 1 | 2 | 1-2 | 1 |

**Key to pigment characters and states** (applicable developmental phases in brackets – pr = protolarvae, fm = flexion mesolarvae, pm = postflexion mesolarvae, mt = metalarvae, ej = early juveniles):

24. Snout (above upper lip or margin of upper jaw and exclusive of nares) [fm-pm]
    1. unpigmented.
    2. pigmented with 1–5 melanophores.
    3. pigmented with 6 or more melanophores.
25. Pigmentation in and along margin of nares (nasal pits) [pr-pm]
    1. absent.
    2. sparse to moderate.
    3. extensive without strong emphasis on anterior and medial margins.
    4. extensive with strong emphasis on anterior and medial margins.
26. Dorsal surface of head [pr-fm]
    1. unpigmented or pigmented only over hindbrain (posterior to middle of eyes).
    2. pigmented over both mid- and hindbrain (anterior and posterior to middle of eyes).
27. Pigmentation across dorsal surface of body between head and last myomere (for specimens with greater than 12 melanophores on dorsal surface) [pr-pm]
    1. not scattered or sparsely scattered with at least a partial, distinct, lengthwise line or narrow band of melanophores on or lateral to dorsal midline.
    2. densely scattered over all or most of back with at least a partial, distinct, lengthwise line or narrow band of melanophores on or lateral to dorsal midline.
    3. densely scattered over all or most of back with no distinct, lengthwise lines or narrow bands of melanophores [characters 28 and 29 NA].
28. Pigmentation on dorsal midline behind head to origin of the dorsal fin (first pterygiophore) or its approximate future origin (about half of standard length) [pr-pm; NA if character 27 is state 3]
    1. absent.
    2. present but sparse--just a few scattered melanophores not forming a distinct line of any length.
    3. present in a short but distinct, continuous or discontinuous line or series of several well-spaced melanophores extending to no more than half the distance.
    4. present in a distinct but discontinuous line or series of at least several well-spaced melanophores extending to or nearly to full length.
    5. present in a distinct continuous or nearly continuous line to or nearly to full length.
29. Pigmentation on dorsal surfaces lateral to midline from shortly behind head to about 2/3 distance to last myomeres [pr-pm; NA if character 27 is state 3]
    1. absent.
    2. sparsely to densely scattered with no distinct, lengthwise lines or narrow bands of melanophores on either side.
    3. scattered or not but with a distinct, short or discontinuous (well separated segments) line or narrow band of melanophores along one or both sides of dorsal midline.
    4. scattered or not but with a distinct, continuous or nearly continuous, full-length line or narrow band of melanophores along each side.
30. Pigmentation on dorsal surface of body between head and last myomere [mt-ej]
    1. scattered more or less evenly (with or without emphasis on distinct lines of melanophores or melanophore clusters on or lateral and parallel to dorsal midline).
    2. scattered in a blotchy or mottled pattern (with or without emphasis on distinct lines of melanophores or melanophore clusters on or lateral and parallel to dorsal midline).
31. Distinct spot or aggregation of pigment at origin of dorsal fin [mt-ej]
    1. absent (or indistinct).
    2. prominent.

(continued)

**Table 69.** Continued.

32. Pigment on or between pterygiophores of dorsal fin [mt-ej]
    1. absent or not obvious (essentially white).
    2. obvious (light to strong) without a distinct spot.
    3. with an obvious spot over posterior two-thirds to half of pterygiophores with some scattered pigment before and/or after.
    4. with an obvious spot over posterior two-thirds to half of pterygiophores with obvious unpigmented spot or area immediately before and/or after.
33. Pigmentation under or immediately along base of dorsal fin [mt-ej]
    1. absent.
    2. present only under or along middle portion, often forming a distinctive "dash" of pigment.
    3. present only under or along middle and posterior portions.
    4. present under or along posterior two-thirds to full length of base with greater intensity and concentration at posterior end.
    5. present full length.
    6. otherwise.
34. Pigmentation under or immediately along base of anal fin [mt-ej]
    1. absent.
    2. present only under or along middle portion, often forming a distinctive "dash" of pigment.
    3. present only under or along middle and posterior portion.
    4. present under or along posterior two-thirds to full length of base with greater intensity and concentration at posterior end.
    5. present full length.
    6. otherwise.
35. Pigmentation around end of notochord or urostyle (uroneural) [pr-pm]
    1. absent.
    2. present but sparse--just a few melanophores.
    3. moderate but not prominent–does not stand out.
    4. present with a prominent series of melanophores along dorsal side only.
    5. present with a prominent series of melanophores along dorsal side, around end, and ventral side.
36. Dark bar of pigment on lateral surface of snout anterior to eye [mt-ej]
    1. absent.
    2. present (usually as a continuation of an intense lateral band from eye to tail).
37. Lateral surface of head posterior to eyes [fm-mt]
    1. unpigmented.
    2. pigmented with 1–5 melanophores.
    3. pigmented with more than 5 melanophores.
38. Pigmentation of horizontal myosepta [pr-mt]
    1. absent.
    2. sparse.
    3. moderate to strong line only along middle of body.
    4. moderate to strong line only along middle and posterior body.
    5. moderate to strong line along entire body (except sometimes immediately behind head).
    6. moderate to strong narrow band along entire body (except sometimes immediately behind head; precursor of a broader lateral band).
39. Line of internal to near-surface pigment over dorsal and dorsolateral surfaces of posterior gut and air bladder, as visible from lateral view [pr-pm]
    1. absent, obscure, or indistinct (can't tell).
    2. does not extend anteriorly to head.
    3. continues anteriorly to head but not beyond.
    4. continues anteriorly in head to or towards anterior margin of auditory vesicle behind eye and has obvious horizontal-y-forming branch extending down behind base of pectoral fin or bud then forward to throat region.
    5. continues anteriorly in head beyond anterior margin of auditory vesicle towards eye and has obvious horizontal-y-forming branch.
    6. continues anteriorly in head to or towards anterior margin of auditory vesicle behind eye but without obvious horizontal-y-forming branch.
    7. continues anteriorly in head beyond anterior margin of auditory vesicle towards eye but without obvious horizontal-y-forming branch.
40. Internal to near-surface pigmentation over dorsal to dorsolateral surfaces of gut or visceral cavity under air bladder as visible from lateral view [fm-pm]
    1. absent.
    2. sparse, up to several melanophores.
    3. moderate in coverage or intensity.
    4. continuous and dark.
41. Lateral surface of body above horizontal myosepta (lateral midline) and below dorsolateral surface (exclusive of pigmentation associated with horizontal myosepta) [fm-mt]
    1. unpigmented.
    2. pigmented with 1–5 melanophores.
    3. pigmented with more than 5 melanophores.

(continued)

**Table 69.** Continued.

42. Lateral surface of body below horizontal myosepta (or lateral midline) but anteriorly above gut and visceral cavity (exclusive of pigmentation associated with horizontal myosepta and air bladder) [fm-mt]
    1. unpigmented.
    2. pigmented with 1–5 melanophores.
    3. pigmented with more than 5 melanophores.
43. Pigmentation on lateral surface of visceral cavity (exclusive of internal near-surface pigment on dorsal and dorsolateral surfaces of gut) [pr-pm]
    1. absent.
    2. sparsely scattered, up to 5 melanophores not forming a line.
    3. moderately scattered with no line or band.
    4. scattered anterior and ventral of mid air bladder with a line extending from mid-air bladder posteriorly to along dorsolateral surface of posterior gut.
    5. scattered or not, but with a continuous or discontinuous line or series of melanophores extending nearly horizontally between pectoral fin and line of pigment above the posterior gut.
    6. scattered or not, but with a continuous or discontinuous line or series of melanophores extending diagonally between heart on ventral or ventrolateral surface and line of pigment above the posterior gut.
    7. otherwise.
44. Basicaudal spot (distinctive pigment spot on lower hypural bones) [fm-mt]
    1. absent.
    2. faint, or light.
    3. dark and prominent.
45. Caudal spot (distinctive spot of pigment at the middle base of the caudal fin, about the size of the pupil or larger, sometimes present as the enlarged end of the lateral band, sometimes extending onto the base of the middle caudal rays) [mt-ej]
    1. absent.
    2. faint, or light.
    3. dark and prominent.
46. Distinctive, large, square melanophores on lateral surface of body [mt-ej]
    1. absent.
    2. present (coverage few to extensive).
47. Lateral band of pigment from head to tail [mt-ej]
    1. absent.
    2. faint to dark and narrow on posteriorly, absent anteriorly.
    3. faint to moderate intensity, sometimes broadening anteriorly, not continuing on lateral surface of head.
    4. dark and narrow posteriorly, becoming much broader (diffuse) and slightly lighter to faint (dusky) anteriorly.
    5. dark and consistently wide for full body length, beginning on lateral surface of head, sometimes ending posteriorly in a slightly wider or disjunct caudal spot.
48. Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent (exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity peritoneum, or gut) [ej]
    1. scattered only partially down to the horizontal myoseptum (lateral midline) or lateral band if present, leaving an unpigmented zone above all or most of the horizontal myosepta or lateral band.
    2. scattered fully and evenly down to the horizontal myoseptum or lateral band with few if any melanophores below the myoseptum or band.
    3. scattered evenly or in mottled pattern (continuous with dorsal and dorsolateral surface pattern) down to horizontal myoseptum or lateral band and at least partially below horizontal myoseptum to bottom-of-eye level.
49. Pigmentation on lateral to ventrolateral surfaces of body below bottom-of-eye level (exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity peritoneum, or gut) [ej]
    1. absent including caudal peduncle.
    2. absent except on caudal peduncle.
    3. present.
50. Pigmentation outlining scales [presence -- ej]
    1. absent.
    2. light (barely evident).
    3. moderate.
    4. bold.
51. Pigmentation under chin (anterior ventral surface of lower jaw) [pr-ej]
    1. absent.
    2. present with one melanophore or more but not in a midline row.
    3. present with two or more melanophores in a midline row.
52. Melanophores on ventral to ventrolateral surfaces or margins of preopercles (below to behind posterior half of eyes) [pr-ej]
    1. absent.
    2. present, but not consisting of or including a distinct oblique row of 3 or more melanophores near or along the margin of either preopercle.
    3. consisting of or including a distinct oblique row of 3 or more melanophores near or along the margin of one or both preopercles.

(continued)

**Table 69.** Continued.

53. Melanophores on ventral surface anterior to heart in branchial (gular) region (between opercles and branchiostegal membranes) [pr-ej]
    1. absent.
    2. present.
54. Melanophores on ventral surface of heart region exclusive of outer margins [pr-ej]
    1. absent.
    2. present.
55. Pigmentation outlining heart cavity [pr-ej]
    1. absent (or obscured).
    2. sparse, or light with ≤5 melanophores.
    3. moderate, at least laterally.
    4. bold along lateral margins only.
    5. bold along lateral and posterior margins.
56. Pigmentation on ventral surface between heart and vent [pr-ej]
    1. absent [characters 57, 58, and 59 NA].
    2. present only as scattered melanophores over all or part of surface [characters 58 and 59 NA].
    3. present only as a partial to continuous line, narrow band, or series of well spaced melanophores along the ventral midline [characters 57 and 59 NA].
    4. present only as partial to continuous lines, narrow bands, or linear series of well-spaced melanophores laterally outlining at least the anterior visceral cavity from behind or lateral to the heart and extending posteriorly onto ventrolateral to lateral surfaces [characters 57 and 58 NA].
    5. present only as partial to continuous lines, narrow bands, or linear series of well-spaced melanophores both on the ventral midline and laterally outlining the anterior visceral cavity [character 57 NA].
    6. present as combination of scattered melanophores with a partial to continuous line, narrow band, or well-spaced linear series of melanophores on the ventral midline and/or outlining the anterior visceral cavity.
57. Scattered pigmentation on ventral surface between heart and vent [pr-ej; NA if character 56 is state 1, 3, 4, or 5]
    1. restricted to anterior region behind heart.
    2. widely spaced and covering most of ventral surface.
    3. otherwise.
58. Pigmentation along ventral midline from shortly behind heart region to near vent [pr-ej; NA if character 56 is state 1, 3, 4, or 5]
    1. absent [potentially applicable only if character 56 is state 6].
    2. present only as a full or partial series of widely spaced melanophores.
    3. present as a full length (or nearly so) continuous or nearly continuous line or narrow band of melanophores.
    4. present as a continuous or nearly continuous line or narrow band of melanophores only under all or most of the preanal finfold.
    5. present as a short continuous or nearly continuous line or narrow band of melanophores extending from the heart towards the origin of the preanal finfold (sometimes in combination with oblique lines of pigment to each side forming a trident-like pattern).
    6. otherwise.
59. Lines, narrow bands, or linear series of well-spaced melanophores laterally outlining at least the anterior visceral cavity from behind or lateral to the heart and extending posteriorly onto ventrolateral to lateral surfaces [pr-pm (generally obscured or lost in mt-ej); NA if character 56 is state 1, 3, 4, or 5]
    1. absent [potentially applicable only if character 56 is state 6].
    2. present but continue only a short distance onto ventrolateral surfaces.
    3. continue onto ventrolateral and lateral surfaces and then along gut to vent.
    4. otherwise.
63. Pigmentation in developing dorsal fin [pm]
    1. absent.
    2. sparse with 5 or fewer melanophores.
    3. at least moderate with 6 or more melanophores.
64. Pigmentation in developing anal fin [pm]
    1. absent.
    2. present.
65. Pigmentation in developing pectoral fins [pm]
    1. absent.
    2. present.
66. Pigmentation in dorsal fin [mt-ej]
    1. present to extensive along principal fin rays with few, if any, melanophores on membranes between rays (but might be present on membranes between branches of rays).
    2. extensive along principal fin rays and notably present (more than just a few melanophores) to extensive on at least a portion of membranes between some or all principal rays (might also be present on membranes between branches of rays).
67. Pigmentation in anal fin (melanophores are sometimes very linear along margins of fin rays and easily overlooked) [mt-ej]
    1. absent.
    2. present but very light with 5 or fewer melanophores.
    3. present but more prominent with 6 or more melanophores.

(continued)

**Table 69.** Continued.

68. Pigmentation in caudal fin [mt-ej]
    1. present to extensive along principal fin rays with few, if any, melanophores on membranes between principal rays (but might be present on membranes between branches of rays).
    2. extensive along principal fin rays and notably present (more than just a few melanophores) to extensive only on proximal portions of membranes between at least some principal rays.
    3. extensive along principal fin rays and notably present (more than just a few melanophores) to extensive on middle or (and) distal portions of membranes between some or all principal rays (might also be present on membranes between branches).
    4. extensive along principal fin rays and notably present (more than just a few melanophores) to extensive over most of membranes (proximal to distal portions) between at least some principal rays.
    5. extensive along entire middle rays, and sometimes on membranes between, but only along, and sometimes between, middle to distal portions of principal rays above and below (proximal portions of these mostly unpigmented).
69. Pigmentation in pectoral fins [mt-ej]
    1. absent.
    2. present but very light with up to 5 melanophores.
    3. present but more prominent with greater than 5 melanophores.
70. Pigmentation in pelvic fins [mt-ej]
    1. absent.
    2. present (but seldom with more than a few melanophores).

**Table 70.** Comparison of diagnostic eye, mouth, and fin position characters for larvae and juveniles (≤40 SL) of native cyprinids of the Gila River Basin. (Key to characters and their states is given below. Rare character states are enclosed in parentheses. NA = not applicable.)

| Character | *Agosia chrysogaster* | *Gila elegans* | *Gila robusta* | *Meda fulgida* | *Ptychocheilus lucius* | *Rhinichthys cobitis* | *Rhinichthys osculus* |
|---|---|---|---|---|---|---|---|
| **Eye Shape** | | | | | | | |
| Protolarvae | 2-3 | 1-2 | 1-3 | (1-2),3 | 1-2 | 2-3 | 1-2 |
| Flexion Mesolarvae | 3 | 1-2 | 2-3 | 3 | 1-2 | (1),2-3 | 1-2 |
| Postflexion Mesolarvae | 3 | 2-3 | 2-3 | 3 | 2-3 | 2-3 | 2-3 |
| **Mouth Position** | | | | | | | |
| Protolarvae | 3-4 | 2,4-5 | 4-5 | 1-2,(4) | 2,4-5 | 4-5 | 3-4 |
| Flexion Mesolarvae | 3 | 2 | 2 | 1 | 2,4 | (3),4 | 3-4 |
| Postflexion Mesolarvae | 3 | 2 | 2 | 1,(2) | 2 | 4 | 3-4 |
| Metalarvae | 3 | 2 | 2-3 | 1-2 | 2-3 | 4 | 4 |
| Juveniles | 3-4 | 2 | 2 | 2-3 | 3 | 3-4 | 4 |
| **Posterior Corner of Mouth** | | | | | | | |
| Protolarvae | 3-4 | 3-4 | 3-4 | 2,(3-4) | 3-4 | 3-4 | 3-4 |
| Flexion Mesolarvae | (2),3 | 3 | 2-3 | 2 | 3 | (2),3 | 3 |
| Postflexion Mesolarvae | 2-3 | 3 | 2-3 | 2 | 3 | 2-3 | 3 |
| Metalarvae | (2),3 | 3 | 2-3 | 2-3 | 3 | 2-3 | 3 |
| Juveniles | 3 | 3 | 3 | 3,(4) | 3 | 1-2 | 3 |
| **Frenum** | | | | | | | |
| Postflexion Mesolarvae | 1-3 | 1,2 | 2 | (1),2 | 2-3 | 2 | 2 |
| Metalarvae | 3 | 2-3 | 2-3 | 2-3 | 3 | 2 | 2-3 |
| Juveniles | 3 | 3 | (2),3 | 3 | 3 | 2 | 3 |
| **Origin of Dorsal Fin** | | | | | | | |
| Metalarvae | 1-3 | 3 | (2),3 | (2),3 | (2),3 | (1),2-3 | 3 |
| Juveniles | 1-2,(3) | 3 | (2),3 | (2),3 | (2),3 | (1),2,(3) | 3 |
| **Insertion of Dorsal Fin** | | | | | | | |
| Metalarvae | 1,(2) | 1-3 | (1),2 | 1-2,(3) | 1-2 | 1,(2) | 2-3 |
| Juveniles | 1,(2) | 2,(3) | 2,(3) | (1),2 | (1),2 | 1-2 | 3 |

**Key to special characters and states** (applicable developmental phases in brackets – pr = protolarvae, fm = flexion mesolarvae, pm = postflexion mesolarvae, mt = metalarvae, ej = early juveniles):

Eye shape [pr-pm]
1. Strongly to moderately oval (dorsoventrally flattened).
2. Slightly but distinctly oval.
3. Round (or very nearly so).

Mouth position [all]
1. Superior–strongly oblique with anterior end of upper lip above middle-of-eye level, lower jaw usually most anterior margin of snout (portion of head anterior to eyes).
2. Terminal–moderately oblique with anterior end of upper lip above bottom- to middle-of-eye level, lips usually even with or the most anterior margin of snout (sometimes slightly behind anterior margin of snout).
3. Low terminal–slightly oblique to horizontal with anterior end of upper lip at or below bottom-of-eye level and either even with or the most anterior margin of snout.
4. Subterminal–slightly oblique to horizontal with anterior margin of upper lip at or below bottom-of-eye level and lips preceded or overhung by anterior margin of snout.
5. Inferior–horizontal (or nearly so) and distinctly on underside of head with lips well behind anterior margin of snout.

Posterior corner of mouth (including lips) relative to eye [all]
1. Distinctly anterior to anterior margin of eye.
2. Below anterior margin of eye, or nearly so.
3. Distinctly posterior of anterior margin of eye but anterior to pupil.
4. Below at least anterior margin of pupil.

Frenum (bridge of tissue between anterior upper lip and rest of snout, no crease between anterior portion of upper lip and portion of snout above, upper lip not protrusible) [pm-jv]
1. Lip not sufficiently developed to assess.
2. Present.
3. Absent (lip completely separated from snout above).

Origin of dorsal fin relative to origin of pelvic fins [mt-jv]
1. Distinctly anterior.
2. Over or very nearly so (difference no more than ± 2% SL).
3. Distinctly posterior.

Insertion (posterior end of base) of dorsal fin relative to posterior margin of vent [mt-jv]
1. Distinctly anterior.
2. Over or very nearly so.
3. Distinctly posterior.

## Non-native -Cyprinids

**Table 71.** Comparison of size (mm SL) at onset of or transition to developmental intervals, gut phases, and other developmental events for larvae and early juveniles of non-native cyprinids of the Gila River Basin. (Rare values in parentheses. NA = not applicable.)

| Character | *Cyprinus carpio* | *Cyprinella lutrensis* | *Pimephales promelas* |
|---|---|---|---|
| **Egg diameter** | 1.3-2.1 | 1.0-1.3 | 1.2-1.6 |
| **Phase/period transitions** | | | |
| Embryo to larva | (3)4-5(6) | 3-4 | 4(5) |
| Proto- to mesolarva | 7-8 | 5 | 6-7 |
| Flexion to postflexion mesolarva | (8)9(10) | 6 | 7-8 |
| Meso- to metalarva | (12)13-16(-18) | (7)8 | 8-9 |
| Larva to juvenile | 16-19(-21) | 10(-12) | 13-15 |
| **Gut phase transitions** | | | |
| 1 to 2 (90° bend) | 8-12(-15) | 8-10 | 8-11 |
| 2 to 3 (full loop) | 12-15 | 26 | 11(12) |
| 3 to 4 (partial crossover) | 16-21 | NA | 15-19 |
| 4 to 5 (full crossover) | ≥(16-)20 | NA | 19-20 |
| **Onset of selected events** | | | |
| Eyes pigmented | [c] | 3 [c] | [c] |
| Yolk assimilated | 6-7(8) | (4)5 | 4-5(6) |
| Finfold absorbed | 16-19(-21) | (9)10(-12) | 13-15 |
| Pectoral-fin buds | [c] | [c] | [c] |
| Pelvic-fin buds | 9-11(12) | 7-8 | 8-9 |
| Pelvic fins adnate[a] | NA | NA | NA |
| Dorsal spine formation [b] | 20-21 (with serrations) | NA | NA |
| Maxillary barbels | 13-15 (corner pair)<br>>32, <41 (anterior pair) | NA | NA |
| **Fin rays first observed** | | | |
| Dorsal, principal | (8)9-11 | 6 | – |
| Anal, principal | 10-11 | (6)7 | – |
| Caudal, principal | 7-8 | 5 | 6-7 |
| Caudal, rudimentary | 9-11 | 7 | – |
| Pectoral | 11-12 | (5)6 | – |
| Pelvic | 12 | 9 | – |
| **Full fin-ray counts first observed** | | | |
| Dorsal, principal | (12)13-16(-18) | 7-8 | 8-9 |
| Anal, principal | 12-13 | (7)8 | 8-9 |
| Caudal, principal | (8)9(10) | 6 | 7-8 |
| Caudal, rudimentary | 15-16(17) | 10(11) | 13-15 |
| Pectoral | (14-)16-17 | 9-10 | – |
| Pelvic | (15-)17-19 | 10 | – |
| **Scales, lateral series** | | | |
| First observed | 13-16 | 12-13 | – |
| Full series first observed | 18-21 | (15)16 | 16-<23 |

[a] Medial margin of fin at least partially connected to body.
[b] Transformation (thickening and elongation) of second (last) rudimentary to a distinctive spine as indicated by length greater than three-quarters that of the first principal dorsal-fin ray.
[c] (Or) before hatching.

**Table 72.** Comparison of selected meristics for larvae and early juveniles of non-native cyprinids of the Gila River Basin. (Character range is followed by the mean, mode, or more typical range. See Figure 4 for methods of counting myomeres and fin rays. ODF = origin of dorsal finfold, OD = origin of dorsal fin, OP2 = origin of pelvic buds or fins, and PV = posterior margin of the vent. Vertebra counts include four for the Weberian complex; dorsal- and anal-fin-ray counts are of principal rays; scale counts are of the lateral line or series. Most data are from Snyder, 1981, and references listed in species accounts there and herein.)

| Character | *Cyprinus carpio* | *Cyprinella lutrensis* | *Pimephales promelas* |
|---|---|---|---|
| **Myomeres to ODF** | | | |
| Protolarvae | – | 9-9, 9 | – |
| Flexion mesolarvae | 10-12, 11 | 7-13, 9 | 10-13, 12 |
| Postflexion mesolarvae | 10-12, 11 | 7-11, 9 | 10-13, 12 |
| **Myomeres to OD** | | | |
| Postflexion mesolarvae | 11-13, 12 | 15-16, 16 | – |
| Metalarvae | 10-12, 11 | 13-19, 16 | 12-16, 15 |
| **Myomeres to OP2** | | | |
| Postflexion mesolarvae | 13-15, 14 | – | – |
| Metalarvae | 11-14, 13 | 12-16, 14 | 12-15, 14 |
| **Myomeres to PV** | | | |
| Proto- & mesolarvae | 26-28, 26-28 | 20-24, 21-23 | 21-25, 23-24 |
| Metalarvae | 25-26, 25 | 19-24, 21 | 22-25, 23 |
| All larvae | 25-28, 25-28 | 19-24, 21-23 | 21-25, 23-24 |
| **Myomeres after PV** | | | |
| Proto- & mesolarvae | 10-12, 11-12 | 12-15, 13-14 | 12-15, 13 |
| Metalarvae | 11-13, 12 | 12-17, 14 | 11-13, 12 |
| All larvae | 10-13, 11-12 | 12-17, 13-14 | 11-15, 12-13 |
| **Myomeres, total** | | | |
| Proto- & mesolarvae | 37-39, 38 | 34-37, 35-36 | 34-38, 36-37 |
| Metalarvae | 36-37, 37 | 34-37, 36 | 34-36, 35 |
| All larvae | 36-39, 37-38 | 34-37, 35-36 | 34-38, 35-37 |
| **Vertebrae** | 32-39, 35-38 | 32-36, 35-36 | 35-38, 36-37 |
| **Dorsal-fin rays** | 16-24, 18-22 [a] | 6-9, 8 | 7-9, 8 |
| **Anal-fin rays** | 5-8, 6 [a] | 7-13, 9 | 7 |
| **Lateral-line scales** | 32-41, 35-38 | 30-40, 32-37 | 40-60, 44-48 |

[a] Spines are hardened lepidotrichia and not separated by use of Roman numerals.

**Table 73.** Comparison of the more diagnostic differences in morphometrics for larvae and juveniles (≤40 mm SL) of non-native cyprinids of the Gila River Basin. (Except as indicated, all data are percentages of standard length, % SL, presented as ranges followed by means. HL = head length measured to the origin of the pectoral fin, AS to OP1. See Figure 4 for other abbreviations and methods of measurement.)

| Developmental Phase<br>Character | *Cyprinus carpio* | *Cyprinella lutrensis* | *Pimephales promelas* |
|---|---|---|---|
| **Protolarvae** | | | |
| Eye diameter [a] | 6-9, 7 | 6-7, 7 | 7-8, 7 |
| AS-to-PE length | 10-13, 11 | 8-9, 9 | 8-10, 9 |
| AS-to-ODF length | 37-47 | 44-49, 47 | 39-45, 42 |
| AS-to-PV length | 70-75, 72 | 62-64, 63 | 61-64, 62 |
| Yolk length [b] | 0-44 | 0-58 | 0-53 |
| Pectoral-fin length [c] | 4-13, 10 | 10-13, 11 | 5-14, 12 |
| Depth at OD [b] | 12-16, 14 | – | – |
| Width at OD [b] | 5-10, 7 | – | – |
| Max. yolk depth [b] | 0-17 | 0-21 | 0-22 |
| Max. yolk width [b] | 0-8 | 0-24 | 0-20 |
| **Flexion mesolarvae** | | | |
| Eye diameter, % HL [a] | 29-32, 30 | 32-35, 33 | 38-47, 40 [I] |
| AS-to-PE length | 12-15, 13 | 9-13, 11 | 12-14, 12 [I] |
| AS-to-OPAF length | 37-45, 39 | 34-38, 37 | – |
| AS-to-ODF length | 46-49, 48 | 42-49, 46 | 41-50, 46 [I] |
| AS-to-PV length | 74-75, 75 | 61-67, 65 | 65-72, 69 [I] |
| Yolk length | 0 | 0 | 0 |
| Pectoral-fin length | 12-15, 13 | 11-15, 13 | 12-14, 12 [I] |
| Depth at OP1 | 16-20, 18 | 11-14, 13 | 13-16, 15 [i,j] |
| Depth at OD [d] | 11-16, 13 | – | – |
| Depth at BPV | 7-8, 7 | 8-13, 10 | – |
| Width at BPE | 13-14, 14 | 12-14, 13 | – |
| Width at OP1 | 10-12, 11 | 9-13, 10 | 10-13, 10 [i,j] |
| Width at OD [d] | 7-8, 7 | – | – |
| Max. yolk depth | 0 | 0 | 0 |
| Max. yolk width | 0 | 0 | 0 |
| **Postflexion mesolarvae** | | | |
| Eye diameter, % HL [a] | 25-38, 29 | 23-38, 32 | 38-47, 40 [I] |
| AS-to-OP1 length | 13-18, 15 | 11-13, 12 | 21-24, 22 [I] |
| AS-to-OP2 length | 26-33, 30 | 21-24, 23 | – |
| AS-to-OPAF length | 29-57, 43 | 37-38, 38 | – |
| AS-to-PV length | 74-77, 76 | 65-67, 66 | 65-72, 69 [I] |
| Pectoral-fin length | 11-16, 13 | 13-16, 14 | 12-14, 12 [I] |
| Dorsal-fin-base length [e,f] | – | 14-15, 14 | – |
| Depth at OP1 | 19-27, 23 | 14-16, 15 | 13-16, 15 [i,j] |
| Depth at OD | 13-25, 20 | 14-15, 14 | – |
| Depth at BPV | 7-15, 12 | 10-12, 11 | – |
| Width at BPE | 15-20, 18 | 12-14, 13 | – |
| Width at OP1 | 11-16, 14 | 10-11, 10 | 10-13, 10 [I j] |
| Width at OD | 7-20, 12 | 7-8, 7 | – |
| **Metalarvae** | | | |
| Eye diameter, % HL [a] | 19-34, 25 | 25-36, 32 | 29-43, 36 |
| AS-to-AE length | 6-8, 7 | 5-7, 5 | 5-5, 5 |
| AS-to-PE length | 13-18, 15 | 12-15, 13 | 13-16, 14 |
| AS-to-OP1 length | 29-35, 32 | 22-28, 25 | 24-30, 27 |
| AS-to-OP2 length | 50-54, 52 | 47-51, 49 | 51-57, 54 |
| AS-to-OD length | 47-51, 49 | 49-54, 52 | 50-57, 54 |
| AS-to-ID length | 79-83, 81 | 63-67, 66 | – |
| AS-to-PV length | 72-77, 74 | 61-67, 64 | 65-75, 71 |
| AS-to-IA length | 80-84, 82 | 74-78, 77 | – |
| Caudal-fin length [g] | 19-25, 22 | 16-26, 19 | 16-23, 20 |
| Pectoral-fin length | 12-15, 13 | 11-18, 13 | 12-15, 13 |
| Pelvic-fin length | 8-10, 9 | 3-12, 8 | 2-10, 6 |
| Dorsal-fin-base length [f] | 31-33, 32 | 13-15, 14 | – |

(continued)

**Table 73.** Continued.

| Developmental Phase<br>Character | *Cyprinus carpio* | *Cyprinella lutrensis* | *Pimephales promelas* |
|---|---|---|---|
| Depth at BPE | 21-24, 22 | 12-18, 15 | 16-22, 19 |
| Depth at OP1 | 25-30, 27 | 14-21, 18 | 16-23, 19[j] |
| Depth at OD | 23-30, 27 | 15-19, 17 | – |
| Depth at BPV | 14-17, 15 | 11-15, 13 | – |
| Depth at AMPM | 8-11, 10 | 8-10, 9 | – |
| Width at BPE | 19-20, 20 | 12-16, 14 | – |
| Width at OP1 | 16-19, 18 | 11-13, 12 | 12-20, 16[j] |
| Width at OD | 14-17, 16 | 8-11, 10 | – |
| Width at BPV | 9-12, 10 | 7-9, 8 | – |
| Width at AMPM | 3-6, 5 | 2-5, 4 | – |
| **Juveniles <40 mm SL** | | | |
| Eye diameter, % HL[a] | 19-26, 24 | 25-36, 32 | – |
| AS-to-AE length | 8-11, 9 | 4-8, 6 | – |
| AS-to-PE length | 15-18, 17 | 12-15,14 | – |
| AS-to-OP1 length | 27-33, 31 | 22-28, 25 | – |
| AS-to-OP2 length | 50-56, 53 | 46-52, 49 | – |
| AS-to-OD length | 46-49, 48 | 47-52, 50 | – |
| AS-to-ID length | 80-84, 82 | 60-67, 63 | – |
| AS-to-PV length | 73-77, 75 | 60-64, 62 | – |
| AS-to-IA length | 81-85, 84 | 73-78, 76 | – |
| AS-to-AFC length | 109-115, 111 | 111-118, 114 | – |
| Caudal-fin length[g] | 18-27, 22 | 20-29, 25 | – |
| Pectoral-fin length | 12-18, 15 | 15-22, 19 | – |
| Pelvic-fin length | 11-17, 14 | 11-17, 14 | – |
| Dorsal-fin length | 37-41, 38 | 20-24, 22 | – |
| Anal-fin length | 14-19, 17 | 17-23, 20 | – |
| Dorsal-fin-base length[f] | 33-36, 34 | 12-15, 13 | – |
| Depth at BPE | 21-24, 23 | 14-18, 16 | – |
| Depth at OP1 | 29-35, 32 | 17-24, 21 | – |
| Depth at OD | 31-36, 34 | 17-25, 20 | – |
| Depth at BPV | 18-23, 21 | 13-20, 17 | – |
| Depth at AMPM | 11-13, 12 | 8-12, 10 | – |
| Width at BPE | 18-21, 20 | 12-16, 14 | – |
| Width at OP1 | 19-23, 21 | 11-16, 14 | – |
| Width at OD | 18-22, 20 | 9-16, 12 | – |
| Width at BPV | 10-17, 14 | 8-14, 10 | – |
| Width at AMPM | 4-9, 6 | 3-7, 4 | – |

[a] Eye diameter = (AS to PE)-(AS to AE); approximated for protolarvae, metalarvae, and juveniles of *Cyprinus carpio* and *Cyprinella lutrensis* by difference between mean, minimum and maximum values in species accounts with range extended by the greater standard deviation, and then, for all but protolarvae, dividing those results by mean HL.

[b] Ignore differences in maximum values because they may be affected by developmental state at hatching.

[c] Ignore differences in minimum values because they may be affected by developmental state at hatching.

[d] OD for protolarvae and early flexion mesolarvae is approximated at one-half of standard length (AS to PHP).

[e] Applicable only to specimens with a full complement of dorsal-fin pterygiophores or principal rays.

[f] Dorsal-fin base = (AS to ID)-(AS to OD); approximated for protolarvae, metalarvae, and juveniles of *Cyprinus carpio* and *Cyprinella lutrensis* by difference between mean, minimum and maximum values in species accounts with range extended by the greater standard deviation.

[g] Caudal-fin length = (AS to PC)-(AS to PHP), total length minus standard length.

[h] Maximum yolk values are approximated using measurements from the largest protolarva with yolk that was analyzed (although found, no flexion mesolarvae with yolk were analyzed for morphometrics).

[I] Data for mesolarvae as whole, not analyzed separately for flexion and postflexion phases.

[j] Maximum body depth or width, probably near or somewhat behind OP1.

**Table 74.** Comparison of size (mm SL) relative to melanophore pigmentation of the eyes and bodies for protolarvae and lateral to ventral peritoneum for metalarvae (M) and early juveniles (J, ≤40 mm SL) of non-native cyprinids of the Gila River Basin. (For peritoneal pigmentation, size is preceded by initials for the applicable developmental intervals. Rare values are given in parentheses.)

| Character | *Cyprinus carpio* | *Cyprinella lutrensis* | *Pimephales promelas* |
|---|---|---|---|
| **Eye pigmentation, protolarvae** | | | |
| Unpigmented | [a] | 3? [a] | [a] |
| Light to moderate | (3)4-5 [a] | 3 [a] | 4 [a] |
| Dark | ≥5 [a] | ≥4 | ≥5 [a,] |
| **Body pigmentation, protolarvae** | | | |
| Unpigmented | (3-4) [a] | 3 [a] | [a] |
| 1-12 melanophores on dorsum | (3-5) [a] | 4-6 | (4) [a] |
| ≥13 melanophores on dorsum | ≥4 [a] | ≥5 | ≥4 [a] |
| **Peritoneal pigmentation** [b] | | | |
| Lateral | | | |
| Absent | – | M ≤9 | MJ (≤15) |
| Sparse or patchy | – | M(J) ≥(9)10 | M all |
| Uniformly speckled | M all | M(J) ≥12 | M ≥11 |
| Uniformly light | – | – | M ≥11 |
| Uniformly dark | – | M(J) ≥(9)10 | J ≥15 |
| Obscured by overlying tissues | MJ ≥15 | J ≥12 | J ≥19 |
| Ventrolateral surfaces | | | |
| Absent | M ≤24 | MJ ≤12 | MJ 11-15 |
| Sparse or patchy | MJ (12-24) | MJ ≥(9)10 | MJ 11-19 |
| Uniformly light | – | J ≥11 | MJ (11-15) |
| Uniformly dark | – | – | J ≥19 |
| Obscured by overlying tissues | J ≥25 | J ≥26 | J ≥(24)25 |
| Ventral surface | | | |
| Absent | M ≤24 | MJ ≤25 | MJ ≤15 |
| Sparse or patchy | – | MJ ≥13 | MJ ≤24 |
| Uniformly light | – | – | J (24-25) |
| Uniformly dark | – | – | J ≥25 |
| Obscured by overlying tissues | J ≥25 | J ≥26 | J ≥39 |

[a] (Or) before hatching.

[b] Pigmentation of the peritoneum is subsurface and should not be confused with surface or cutaneous pigmentation; some near-surface pigmentation in protolarvae and mesolarvae becomes distinguishable as peritoneal pigment in metalarvae. Also, pigment is usually apparent in the dorsal and dorsolateral aspects of the peritoneum of smaller metalarvae (and earlier larvae) and should not be interpreted as pigment in the lateral region. In juveniles, possibly including specimens smaller than recorded, melanophore pigmentation in the peritoneum may be obscured by overlying muscle or, especially in living and alcohol-preserved specimens, integument with a silvery lining of iridophores.

**Table 75.** Comparison of selected melanophore pigmentation patterns for larvae and juveniles (≤40 SL) of non-native cyprinids of the Gila River Basin. (See Table 69 for key to characters and their states; character numbers are those used in the computer-interactive key. Rare character states are enclosed in parentheses. NA = not applicable.)

| Character number | *Cyprinus carpio* | *Cyprinella lutrensis* | *Pimephales promelas* |
|---|---|---|---|
| **Protolarvae (after pigment is well established)** | | | |
| 25. | 1-2 | 1-2 | 1 |
| 26. | 1-2 | 1-2 | 1-2 |
| 27. | 2 | 1 | 1 |
| 28. | 1-2 | 1 | 1 |
| 29. | 1-2 | 1 | 4 |
| 35. | 1,3,5 | 1 | 2,5 |
| 38. | 1-2 | 1,3 | 2,5 |
| 39. | 4,6 | 1 | 1 |
| 43. | 2-3,5 | 1,6 | 3 |
| 51. | 1-2 | 1 | 1 |
| 52. | 1 | 1 | 3 |
| 53. | 1 | 1-2 | 1 |
| 54. | 1 | 1 | 2 |
| 55. | 1 | 2 | 1 |
| 56. | 1-2 | 1,4 | 2,4 |
| 57. | NA,2 | NA | NA,3 |
| 58. | NA | NA | NA |
| 59. | NA | NA,2 | NA,4 |
| **Flexion mesolarvae** | | | |
| 24. | 3 | 1 | 2-3 |
| 25. | 2-3 | 1 | 1-2 |
| 26. | 2 | 1 | 1-2 |
| 27. | 2-3 | 1 | 1,3 |
| 28. | NA,2 | 1,3 | 1,3 |
| 29. | NA,2-3 | 1,4 | 1,4 |
| 35. | 2-3 | 1 | 1,4 |
| 37. | 2-3 | 1 | 2-3 |
| 38. | 2 | 1,4 | 4-5 |
| 39. | 4,7 | 1,6 | 4,6 |
| 40. | 1-2 | 1 | 1 |
| 41. | 3 | 1 | 1-2 |
| 42. | 2-3 | 1 | 1-2 |
| 43. | 2-3 | 1 | 3,6 |
| 44. | 1,3 | 1 | 1 |
| 51. | 2 | 1-2 | 1-2 |
| 52. | 1 | 1-2 | 3 |
| 53. | 1 | 1-2 | 2 |
| 54. | 1 | 1 | 1 |
| 55. | 1 | 2,4 | 4 |
| 56. | 2 | 1,4 | 2 |
| 57. | 2 | NA | 2 |
| 58. | NA | NA | NA |
| 59. | NA | NA,3 | NA |
| **Postflexion mesolarvae** | | | |
| 24. | 3 | 1 | 3 |
| 25. | 2-3 | 1 | 1 |
| 27. | 2-3 | 1 | 2-3 |
| 28. | NA,5 | 1,3 | 5 |
| 29. | NA,2 | 2-3 | 3 |
| 35. | 1,4 | 1 | 1 |
| 37. | 3 | 1 | 3 |
| 38. | 2,4 | 4 | 5 |
| 39. | 1 | 6 | 6 |
| 40. | 1 | 1-2 | 1 |
| 41. | 3 | 1 | 3 |
| 42. | 3 | 1 | 2-3 |
| 43. | 1,3 | 1,6 | 6 |
| 44. | 3 | 1-2 | 1,3 |
| 51. | 2 | 1 | 2 |

(continued)

**Table 75.** Continued.

| | | | |
|---|---|---|---|
| 52. | 1 | 1 | 3 |
| 53. | 1 | 1 | 2 |
| 54. | 1 | 1 | 1-2 |
| 55. | 1 | 2 | 4 |
| 56. | 1-2 | 1-2 | 2 |
| 57. | NA,2 | NA, 1 | 2-3 |
| 58. | NA | NA | NA |
| 59. | NA | NA | NA |
| 63. | 3 | 1 | 2-3 |
| 64. | 1-2 | 1 | 2 |
| 65. | 1-2 | 1 | 1-2 |
| **Metalarvae** | | | |
| 30. | 1 | 1 | 1 |
| 31. | 1 | 1 | 1 |
| 32. | 1-2 | 1-2 | 1-2 |
| 33. | 2,5 | 5-6 | 2,5-6 |
| 34. | 5 | 5 | 5 |
| 36. | 1 | 1 | 1 |
| 37. | 3 | 1-2 | 3 |
| 38. | 4 | 3-4 | 4-5 |
| 41. | 3 | 1 | 2-3 |
| 42. | 3 | 1 | 1-3 |
| 44. | 3 | 1-3 | 1-2 |
| 45. | 1-3 | 1 | 1 |
| 46. | 1 | 1 | 1 |
| 47. | 1 | 1 | 1 |
| 51. | 1-2 | 1 | 1-2 |
| 52. | 1-2 | 1 | 1-3 |
| 53. | 1 | 1 | 1-2 |
| 54. | 1 | 1 | 1-2 |
| 55. | 1 | 1 | 1 |
| 56. | 1-2 | 1 | 1-2,4 |
| 57. | NA,2 | NA | NA,1-2 |
| 58. | NA | NA | NA |
| 66. | 1-2 | 1 | 1 |
| 67. | 3 | 1 | 1,3 |
| 68. | 1 | 1 | 1 |
| 69. | 1,3 | 1 | 1,3 |
| 70. | 1 | 1 | 1 |
| **Juveniles** | | | |
| 30. | 1 | 1 | 1 |
| 31. | 1 | 1 | 1 |
| 32. | 2 | 1-2 | 2 |
| 33. | 5 | 1,5 | 2,5 |
| 34. | 1,5 | 1,3,5 | 1,3,5 |
| 36. | 1 | 1 | 1 |
| 45. | 1-3 | 1 | 1,(2),3 |
| 46. | 1 | 1 | 1 |
| 47. | 1 | 1-2 | 1-3,5 |
| 48. | 3 | 1-3 | 1-3 |
| 49. | 2-3 | 1,3 | 1,3 |
| 50. | 1-3 | 1,3-4 | 1,3-4 |
| 51. | 1 | 1-2 | 1-2 |
| 52. | 1 | 1 | 1 |
| 53. | 1 | 1-2 | 1,(2) |
| 54. | 1 | 1 | 1 |
| 55. | 1 | 1 | 1 |
| 56. | 1 | 1 | 1 |
| 57. | NA | NA | NA |
| 58. | NA | NA | NA |
| 66. | 2 | 1-2 | 1 |
| 67. | 1,3 | 1,3 | 1,3 |
| 68. | 1,4 | 1 | 1 |
| 69. | 1,3 | 1-3 | (1),3 |
| 70. | 1-2 | 1 | 1-2 |

**Table 76.** Comparison of diagnostic eye, mouth, and fin position characters for larvae and juveniles (≤40 SL) of non-native cyprinids of the Gila River Basin. (Key to characters and their states is given below. Rare character states are enclosed in parentheses. NA = not applicable.)

| Character | *Cyprinus carpio* | *Cyprinella lutrensis* | *Pimephales promelas* |
|---|---|---|---|
| **Eye Shape** | | | |
| Protolarvae | 2-3 | 1-2 | 2-3 |
| Flexion Mesolarvae | 3 | 1,(2) | (1),2-3 |
| Postflexion Mesolarvae | 3 | 1,(2) | 3 |
| **Mouth Position** | | | |
| Protolarvae | 2-3,5 | 2,5 | 3,5 |
| Flexion Mesolarvae | 2 | 2 | 2 |
| Postflexion Mesolarvae | 2-3 | 2 | (1),2 |
| Metalarvae | 3 | 1-2 | 2 |
| Juveniles | 2-3 | 1-2 | 2 |
| **Posterior Corner of Mouth** | | | |
| Protolarvae | 2-4 | 3-4 | 3-4 |
| Flexion Mesolarvae | 2 | 3 | 2 |
| Postflexion Mesolarvae | 2 | 2-3 | 2 |
| Metalarvae | 1-3 | 2 | 1-2 |
| Juveniles | 1-2 | 2 | 1,(2) |
| **Frenum** | | | |
| Postflexion Mesolarvae | 3 | 2 | 3 |
| Metalarvae | 3 | 2-3 | (2),3 |
| Juveniles | 3 | 3 | 3 |
| **Origin of Dorsal Fin** | | | |
| Metalarvae | 1 | 3 | 2-3 |
| Juveniles | 1-2 | 3 | (1),2 |
| **Insertion of Dorsal Fin** | | | |
| Metalarvae | 3 | 1-2 | 1,(2) |
| Juveniles | 3 | 2 | 1,(2) |

**Key to special characters and states** (applicable developmental phases in brackets – pr = protolarvae, fm = flexion mesolarvae, pm = postflexion mesolarvae, mt = metalarvae, ej = early juveniles):

Eye shape [pr-pm]
1. Strongly to moderately oval (dorsoventrally flattened).
2. Slightly but distinctly oval.
3. Round (or very nearly so).

Mouth position [all]
1. Superior–strongly oblique with anterior end of upper lip above middle-of-eye level, lower jaw usually most anterior margin of snout (portion of head anterior to eyes).
2. Terminal–moderately oblique with anterior end of upper lip above bottom- to middle-of-eye level, lips usually even with or the most anterior margin of snout (sometimes slightly behind anterior margin of snout).
3. Low terminal–slightly oblique to horizontal with anterior end of upper lip at or below bottom-of-eye level and either even with or the most anterior margin of snout.
4. Subterminal–slightly oblique to horizontal with anterior margin of upper lip at or below bottom-of-eye level and lips preceded or overhung by anterior margin of snout.
5. Inferior–horizontal (or nearly so) and distinctly on underside of head with lips well behind anterior margin of snout.

Posterior corner of mouth (including lips) relative to eye [all]
1. Distinctly anterior to anterior margin of eye.
2. Below anterior margin of eye, or nearly so.
3. Distinctly posterior of anterior margin of eye but anterior to pupil.
4. Below at least anterior margin of pupil.

Frenum (bridge of tissue between anterior upper lip and rest of snout, no crease between anterior portion of upper lip and portion of snout above, upper lip not protrusible) [pm-jv]
1. Lip not sufficiently developed to assess.
2. Present.
3. Absent (lip completely separated from snout above).

Origin of dorsal fin relative to origin of pelvic fins [mt-jv]
1. Distinctly anterior.
2. Over or very nearly so (difference no more than ± 2% SL).
3. Distinctly posterior.

Insertion (posterior end of base) of dorsal fin relative to posterior margin of vent [mt-jv]
1. Distinctly anterior.
2. Over or very nearly so.
3. Distinctly posterior.